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TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. II.

SECOND ANNUAL MEETING

NEW YORK, JANUARY 21-23,

1896.

PUBLISHED BY THE SOCIETY,
AT THE OFFICE OF THE SECRETARY,
NEW YORK CITY.

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OF

THE AMERICAN SOCIETY

OF

Heating and Ventilating Engineers,

1896-1897.

COMPULSORY LEGISLATION.

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PROF. J. H. KINEALY, Washington University, St. Louis, Mo., Chairman.
H. J. BARRON, Cable Building, New York.
WM. MCMANNIS, Engineer to the Board of Education, 146 Grand Street, New York.

TESTS.

A. A. CARY, 28 Cliff Street, New York.
B. F. STANGLAND, 45 Fulton Street, New York.
HENRY ADAMS, Supervising Architect's Office, Washington, D. C.

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XII

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

SECOND ANNUAL MEETING.

New York City, Jan. 21, 22, and 23, 1896.

OPENING SESSION, TUESDAY MORNING, JAN. 21.

The second annual meeting of The American Society of Heating and Ventilating Engineers was called to order at 11 A. M. on Tuesday, January 21st, 1896, by President Stewart A. Jellett, in the hall of the American Society of Mechanical Engineers, 12 West 31st street, New York city.

The President:—The secretary will call the roll of members.

Secretary Hart called the roll and the following members were present:

Adams, Henry, Washington, D. C.
Adams, Homer, Allentown, Pa.
Andrus, Newell P., Brooklyn.
Barron, Hugh J., New York.
Barwick, Thomas, New York.
Bennett, Wm. B., Rutland, Vt.
Blackmore, J. J., New York.
Blackmore, L. R., New York.
Brooks, E. J., Bridgeport, Conn.
Burns, Samuel, New York.
Carpenter, B. Harold, Wilkes-Barre, Pa.
Carpenter, Prof. R. C., Ithaca, N Y.
Cary, A. A., New York.
Chew, Frank K., New York.
Clark, Wm. H., Lebanon, Pa.
Cobb, Geo. B., Plainfield, N. J.
Connelly, John, New York.
Cryer, A. A., New York.
Cryer, T. B., Newark, N. J.
Davidson, McClellan, Taneytown, Md.
Dean, Mark, Boston.
Dewey, Wm. H. New York.
Edgar, A. C., Philadelphia.
Eisert, Hermann, Baltimore, Md.
Fish, John A., Boston.
Goodrich, J. A., New York.
Gormly, John, Philadelphia.
Hadaway, W. S., New York.
Hart, L. H., New York.
Harvey, Andrew, Detroit.
Hill, Wm. H., New York.
Hoffman, Geo. D., Chicago.
Jellett, Stewart A., Philadelphia.
Joslin, Herbert A., Springfield, Mass.
Kenrick, A. E. Brookline, Mass.
Lincoln, Chas. C., New York.
Loeb, Howard A., Philadelphia.
Mackay, W. M., New York.
Mappett, A. S., New York.
McKeever, Wm. H., New York.
McMannis, Wm., New York.
Onderdonk, Chas. S., Philadelphia.
Paul, Andrew G., Boston.
Payne, John A., Providence, R. I.
Plastow, Geo. W., Jersey City.
Quay, D. M., Chicago.
Russell, Wm. A., New York.
Scollay, U. G., Brooklyn.
Seward, P. H., New York.
Sherman, LeRoy B., New York.
Stangland, B. F., New York.
Steele, Geo. P., Philadelphia.
Tompkins, S. D., Jersey City.
Weymouth, Geo. H., New York
Wilkinson, W. B., New York.
Wilson, J. J., Philadelphia.
Wolfe, W. F., Boston.

The President:—Next in the order of business is the reading of the minutes of the previous meeting.

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Secretary Hart:—The minutes of the previous meeting are all contained in the printed copy of the transactions which has been sent to every member of the society. I therefore hope that the reading of the minutes will be dispensed with.

Mr. William Mackay:—I move, Mr. President, that we do away with the reading of the minutes. (The motion was carried.)

The President then delivered his annual address.

The President:—The next on the programme will be the report of the secretary.

Secretary Hart submitted the following report:

SECRETARY'S REPORT.

The reports which you will receive from your board of managers and council will give you an idea of the progress and increase in membership of your society during the past year, while the report of your treasurer shows its financial standing.

In most instances the initiatory as regards making application for membership has been taken by the person desirous of becoming a member; while this is especially gratifying, I believe every member should interest himself in placing the advantages of the society in the right light before such workers in our field as would make desirable members.

I believe that the society in electing its council should see that at least a majority of such council are located in one city, Chicago, Boston, Philadelphia, or New York.

It is necessary that such council should elect a secretary to take charge of all applications, send them to other members of the council, and examine into them carefully before returning them to the general secretary for the final vote; if this suggestion is carried out, I believe the society will soon have knowledge of its beneficent effects.

In the matter of papers to be read at our annual meeting, members have not taken the interest in them that they should. The papers which will be read and discussed at this meeting all came very late, one of them after the first of the year. Technical papers must be carefully edited, tables, data, and formulas accurately set up, and this requires time. One of these papers alone was four days at the printing office before first proofs were received. Your secretary cannot agree to submit printed copies for your consideration ten days in advance of the meeting if this is to continue.

It hardly seems to me that members realize that the work which this society is doing, and will do, is watched with the greatest interest by our leading universities, technical institutions, architects,

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and others interested in the best methods of heating and ventilation. The society has a great work before it, and can, by establishing standards, protect the probable purchaser of apparatus used in heating and ventilation from the enthusiastic manufacturer who has but recently entered into competition for business in this line, and whose bank account is still intact, who claims that by peculiar construction his apparatus will do so much more and better work than other apparatus, which time and costly experience has taught the maker to believe is correct.

I am acquainted with members of this society who are constantly on their guard lest they shall "give away" something that they believe the other fellow doesn't know. This is all a mistake; a man who is an adept in any line will always be in the front rank, and the members who take part in these discussions and write papers for this society will become much more widely known than ever before. Those people who have need of engineering skill will hear of them in this way, and the result will, I most positively believe, be much more beneficial to them in every way.

I hope the members will give this careful thought, and that for the next meeting they will commence early to get their facts together for papers. Start right away after the meeting, write your secretary if you have a doubt as to the interest the society will take in your proposed subject; he will communicate with your council, and they will give you any help possible. The earlier you send your paper in the better. The first of July for the January meeting is not too soon. They must go to the council for approval, but will not be edited until about November 1st; in the meantime should any questions arise affecting the paper, you could, by communicating with your secretary, make any corrections necessary. By carrying out these suggestions, the work of preparing the annual programme could be greatly facilitated.

Your secretary should receive instructions as to how he should proceed in the case of members who are over one year in arrears with their annual dues. The constitution provides that members shall be liable to expulsion. As the society increases in membership there is no doubt but that this question will become a very important one, and action should be taken at this time.

I desire to thank your president, board of managers, and your council for their kind co-operation during the past year, and my earnest wish is that this society will grow to be a power in the land, as any great institution should that is working for the betterment of mankind.

The President:—We will now have the report of our treasurer.

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Mr. J. A. Goodrich, the treasurer of the society, presented the following report:

TREASURER'S REPORT.

Cash on hand, January 1st, 1895 (Date of last report.)	$493.18
Cash received since that date	992.36
	$1,485.54
Disbursements	$1,112.28
Balance on hand in Washington Trust Co.	$373.26

There are no unpaid bills in the hands of the treasurer, except one for stamps and stationery to the amount of $3.49, which is submitted herewith. The secretary advises that there is due the society for initiation fees $190.00; for dues $270.00.

The President:—Gentlemen, you have heard the report of our treasurer and you see that the balance is on the right side. Next in order is the report of the chairman of the board of managers.

Mr. B. F. Stangland:—Mr. President, the chairman of the board of managers is not here, and I will ask Mr. Hart to read the report that was submitted.

Secretary Hart read the following report:

REPORT OF BOARD OF MANAGERS.

Your board of managers have held eight business meetings during the past year in addition to the meeting held in Philadelphia last June. They have looked carefully after the interests of the society, which they are pleased to report is in a flourishing condition, having added some 27 members during the past year, making a total of over 100 members, associates, and juniors. The society has met all obligations, and the funds are in a healthy condition; they have adopted a pin badge to be worn by members and which can be secured through the secretary; they would suggest that in the coming election of officers at least three members of the council be selected from one city or vicinity, so that they could hold more frequent meetings, preventing delay in acting upon applications for membership. They have not been able to decide and order certificates of membership, feeling that the amount in the treasury would not warrant this expense, but would suggest that this matter be taken up by the new board of managers elected at this meeting.

The President:—Next in order is the report of the chairman of the council. The chairman of the council is not present.

Secretary Hart read the report of the chairman of the council, as follows:

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REPORT OF COUNCIL.

Your council would make the following report through its chairman regarding the admission of members during the past year. The number of persons who have applied for membership in the following classes is as follows: Members, 22; associates, 5; juniors, 4. The following have been elected by letter ballot to the various classes: Wm. Harry Dewey, New York, Norman S. Kellogg, Boston, Mass., Henry Smith Downe, London, Eng., David M. Nesbit, London, Eng., Alfred S. Kenrick, Brookline, Mass., Wm. H. Clark, Lebanon, Pa., Chas. B. J. Snyder, New York, Herbert A. Joslin, Springfield, Mass., George I. Rockwood, Worcester, Mass., McClellan Davidson, Taneytown, Md., Miles C. Huyett, Chicago, Ill., Wm. Ogden Steele, New York, John J. Hogan, Middletown, N. Y., John G. Sorgen, Portland, Ore., Chas. Fox Tay, San Francisco, Cal., Emery E. Dunning, Milwaukee, Wis., Wm. S. Hadaway, New York, members; Geo. H. Weymouth, New York, Wm. H. McKeever, New York, Wm. B. Bennett, Rutland, Vt., juniors; Samuel D. Tompkins, New York, Thomas Thompson, Scranton, Pa., Andrew G. Paul, Boston, Mass., Edward N. Squires, Geneva, N. Y., Frank K. Chew, New York, Guy T. Ahrens, Davenport, Ia., Wm. C. Joy, New York, associates.

The society now numbers 102 persons who constitute its membership in the various classes. Considering the fact that the society has just entered upon the second year of its existence and that a very high standard of membership has been adopted and rigidly adhered to, these results are gratifying.

It will be noticed by a study of our list of members that very few manufacturers of heating apparatus have been admitted to membership. This is no doubt due to the policy adopted at the first organization of the society. While the writer respects the sentiments which prompted the adoption of such a policy at the time, he is now of the opinion that the continuance of this action is no longer necessary.

The society was started as a distinctly engineering society, and it seemed necessary to rigidly cut loose from all commercial influences in order to clearly establish the objects and desires of the association. The existence of the society for the past two years and its great success in securing the cooperation of the best engineering talent in the country have served to establish its principles so thoroughly that the success of its future from this time forward cannot be questioned.

It would seem for these reasons to the chairman of the committee that we might with propriety extend invitations to such of the

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manufacturers of heating apparatus as meet the standard of requirements laid down by the society. There are various reasons for this, some of which may be mentioned; the contact of the manufacturer with a large class of consumers results in obtaining data and coefficients, which, if placed before the society, would be of great value in the solution of engineering questions; second, the manufacturer could add much information of value to the engineer relating to the preparation of the various articles required in this great art; third, the manufacturer himself is an engineer by virtue of his occupation.

We can, I think, offer the manufacturer fully as many advantages in return in the information which we can give relating to the needs and desires of those who design systems of heating and ventilating. I do not advocate any change in our requirements, I do not advocate any lowering of the standard of admission, but I do advocate the consideration of the change in policy as indicated. It is very important for the future of this society that it be maintained an engineering society with as high a standard of admission as possible, and it is essential to its existence that commercial questions be excluded.

The question of having more than one meeting per year is one which no doubt should soon receive consideration. It is the writer's opinion that during the period of formation of the society, which will probably extend through one more year, that one meeting per year will answer every practical purpose. It is desirable to grow rapidly, but it is more desirable to make no mistakes and for that reason it seems to your chairman that the conservative policy carried out during the past year is a very excellent one and that, for the present at least, one meeting per year will be better than two or more.

The papers presented for your consideration can, I think, be considered as equal to those in every respect which have been presented to the older engineering societies, and in this respect the society is to be congratulated, since the value of the society must depend largely upon the literature which is published under its auspices.

The discussion of the papers submitted often brings out facts of more value than those of the paper. In this respect the proceedings of our first meeting are complete, and it is seldom that a volume has been issued in which the discussions are as valuable as in the first volume of this society.

The President:—The next on our programme are the reports of special committees. I will ask for the report of the committee on standards.

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The report of the committee on standards was read by Mr. H. J. Barron, as follows:

REPORT OF COMMITTEE ON STANDARDS.

Your committee to whom was referred the problem of a minimum standard of ventilation for all kinds of buildings has given the subject careful consideration, and in order to arrive at a conclusion has sought information from three sources:

1. The writings of recognized authorities on ventilation.
2. The standards of ventilation adopted in European countries.
3. The results of experience in this country.

A very little work sufficed to show the committee that there was a wide divergence of opinion among authorities as to the proper amount of air to be supplied per minute per person to crowded rooms. It was found that the amounts recommended by authorities varied from four to 60 cubic feet per minute for buildings such as schools, churches, and public buildings, where there was no particular poisonous matter in the air, as is met with in hospitals and places occupied by sick people. This difference of opinion was due partly to the difference in opinion as to what should be considered the limit of impurity of the air, as indicated by the number of parts of carbon dioxide in 10,000 parts of the air; partly to the fact that in some cases the estimate of the air required was based upon the supposition of perfect mixing and diffusion of the fresh air with the impure air already in the room, while in other cases the supposition was that the mixing and diffusion was very imperfect and bad. Some authorities, also, modified their estimate of the amount of air required according to the age of the persons to occupy the room, giving less air to young people than to youths, and less to youths than to grown persons. It may be said that before 1850 most authorities would consider 1,000 to 1,200 cubic feet per hour per person as ample ventilation for rooms inhabited by healthy persons. But Pettenkofer, Grassi, Parkes, and others have shown by later works that 1,000 or 1,200 cubic feet per hour per person is not sufficient even under the best conditions as to diffusion and mixing and they recommend 2,000 to 2,100 cubic feet of air per person per hour as minimum amount to keep the atmosphere of the room from being offensive to the senses. Some later writers claim that even 2,000 cubic feet of air per hour per person is hardly sufficient for even the minimum amount, but the concensus of opinion among the latter authorities appears to be that the amount of air supplied per hour to healthy persons should be as large as possible, and that

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for healthy adults it should never be less than about 2,000 cubic feet per person.

Some authorities consider that as children use less air in breathing than grown people they need not be supplied with so large an amount of air per hour for ventilation; others take the view, which, in the opinion of your committee, is the correct one, that as children are more apt to take diseases and are more susceptible to the bad effects of impure air, the same, or very nearly the same, amount of air should be provided for each child that is provided for each adult.

Authorities usually consider that each gas light will require as much air as one and one-half to five persons, depending upon the number of cubic feet of gas burned per hour and the composition of the gas.

In order to get information as to the standards of ventilation in European countries, letters of inquiry asking if there was any prescribed standard of ventilation for schools and public buildings in that particular place, and what that standard was, were sent to London, Paris, Berlin, Rome, St. Petersburg, Madrid, Vienna, Brussels, Copenhagen, Athens, Hague, Stockholm, Berne, Lisbon, and also to Ottawa, Canada, Halifax, N. S., and Melbourne, N. S. W. The letters were sent to the United States representatives. While answers were received to many of the letters, little information of value to your committee was obtained. In some cases the answers to the letters merely gave information where to seek for further information. It had been hoped that valuable information would be obtained from London, Paris, and Berlin, but no answer has been received from either Paris or Berlin; and in London there is no prescribed standard of ventilation for the schools, but "the architect uses his judgment with regard to the arrangements for ventilation." Rome has very full and complete regulations as to the schools; each pupil must have from four to five cubic meters (141 to 177 cubic feet) of space, and the air must be renewed from three to four times per hour, making from 425 to 710 cubic feet per pupil per hour. There is no prescribed standard of ventilation in Russia, "the climate being so severe as to require the windows to be sealed during six months of the year."

In Switzerland there is no prescribed standard for the schools, but in some of the later schools they are requiring from 10 to 15 cubic meters (351 to 530 cubic feet) per pupil per hour. In Ottawa, Canada, the official regulations prescribe that there shall be at least 250 cubic feet of space for each pupil and that air must be changed three times an hour.

Experience in this country has brought about the tacit acceptance

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of 1,800 cubic feet of air per hour per pupil as the standard amount for ventilation in schools. It cannot be said that any one person or set of persons is responsible for the adoption of this amount as a standard, but it appears to be due to a process of gradual evolution of our schoolhouses. Those who have had much to do with the ventilation of schools will usually assert, as a result of their experience, that with less than 1,800 cubic feet of air per hour per pupil the air in school rooms will become offensive.

As a result of its investigation your committee recommends:

1. That for all buildings, such as schools and asylums occupied almost entirely by children and youths under fifteeen years of age, the minimum amount of air for ventilation shall be 1,800 cubic feet per hour per person.

2. That for all buildings occupied by persons over fifteen years of age the minimum amount of air for ventilation shall be 2,000 cubic feet per hour per person.

3. That for buildings lighted in part or wholly by gas the minimum amount of air supplied for each gas light shall be 3,000 cubic feet per hour.

Secretary Hart:—I would like to read a letter from Prof. Kinealy.

"I wish you would bring the matter of investigating the ventilation of schools before the society and see if it is not willing to make a small appropriation to cover the cost of an investigation. A circular letter of inquiry, asking a series of questions, could be sent to every town and city in this country and Europe. The appropriation must cover the cost of making translations of foreign letters. I am sure much information of value and interest would be obtained. In 1883 Mr. H. W. Wheeler, of Brooklyn, made an investigation of the ventilation of the schools in this country, and in 1889 I made a partial investigation. The investigation, however, should include Europe, in order to put a stop to these persons who are continually telling how much better the schools are ventilated in Europe than they are in this country. In this connection I refer you to an abstract of a report of the chairman of committee on school hygiene, published in Science of Dec. 20th, 1895. I think it is evident that the writer of the report has either no knowledge, or very unreliable knowledge, of the ventilation of European schools. I think it is safe to say that we have in this country some of the best ventilated schools in the world. It is also true, however, that we have some of the poorest ventilated schools. A thorough investigation would enable us to acquire a mass of information that could be gotten in no other way, and if it was done by the society the information would belong to all the members and be at their command at any time."

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The President:—I will now call for the report of the committee on compulsory legislation.

Mr. W. M. Mackay read the following report:

The committee on compulsory legislation has been unable to meet as a whole since the last annual meeting. I met Mr. B. Harold Carpenter, the secretary of the committee, at the meeting in Philadelphia, last June, and went over the subject with him, and finding that it would be impossible to have a meeting of the full committee, we arranged to conduct the business so far as possible by correspondence, getting the views of the different members of the committee, and others versed on the subject, for the purpose of forming a report.

This correspondence is in the hands of the secretary, and as we felt that we could hardly form a report from it without at least a quorum of the committee, I would suggest that these letters be read at this time as a continuation of this report, and that we receive further instructions from the society, and that in the event of any of the members of the committee being unable to act, that their places be filled at this meeting to facilitate further action on this important subject. I have felt and would suggest that the word heating be added to this clause, feeling that it would help us in many cases in securing legislative action.

The President:—Gentlemen, you have heard the report, with the suggestion that the letters be read. What is your action on this report? It will probably give us more complete information as to what the committee has done if we have the correspondence read. It would be necessary to have a motion to that effect.

On motion it was agreed that the correspondence referred to in the report be read to the meeting. Mr. B. H. Carpenter then read the correspondence, which consisted of letters from Mr. W. M. Mackay, Mr. L. H. Prentice, Mr. S. A. Jellett, Mr. William J. Baldwin, Rufus R. Wade, Chief of Massachusetts District Police, and James A. Harding. Extracts from the letters of Messrs. Baldwin, Jellett, and Wade, which were of the most interest, are presented in the order named, as follows:

William J. Baldwin:—"I have your letter in relation to compulsory legislation on public buildings. I take it for granted that it relates very largely to the ventilation of schools, courthouses, etc. It is a very broad subject, and one that, should I be requested to say anything at all about, I would desire to give considerable preparation to. Of course, the Massachusetts law you will obtain, and the laws of other states bearing on the subject. For schools I would suggest that you should not ask much more air per hour than the

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Massachusetts law requires, 1,800 cubic feet per hour per capita. I think 2,000 cubic feet is a very liberal allowance in schools. In the sitting of courthouses it is a difficult thing to fix a per capita, as the rooms are large and the sitting not very great compared with the space inside the railing where the lawyers and lawyers' witnesses, jury, and judge sit. In this case, I would suggest a unit of floor space, a square yard of something else, and insist on, say, 1,000 cubic feet per unit of floor space per hour. Of course, sometimes the rooms are crowded, while at other times there are only a few persons outside those necessary to hold court. I simply offer it as a suggestion in the treatment of courthouses.

"In the matter of jails or state prisons, you will have to consider so much for floor of cell, say, not less than 1,000 nor over 2,000 cubic feet, but with the provision that when prisons are crowded, and prisoners doubled in cells, that the officials will either have to provide a double quantity of air or not 'double up.' In hospitals and poor houses, I think it would be proper to take what is generally accepted as a minimum for hospitals—3,000 cubic feet per bed per hour. I would put no restrictions on the method of admitting the air. I would, however, try to bar all furnaces in which there is but a single partition between the fire and the air space. I would not bar a hot water furnace or a steam furnace, but I would any furnace through the walls of which gases can pass. On this subject you will meet with a great deal of opposition, as the furnace interest is so large, and it is perhaps well to touch on it lightly and not to insist on anything specific for the present, as it might be the means of killing the whole legislative action."

Stewart A. Jellett:—"First, we must clearly define, 'What is a public building?' I take it that it includes all legislative assembly buildings; all municipal and courthouse buildings; all public school buildings, insane asylums, minors, and other hospitals, state reformatories, houses of refuge, prisons, etc., supported wholly by the state. But does it include institutions of learning, hospitals, asylums, state normal schools, and other institutions supported in part only by the state, and in whose management the state is not represented, except in so far as the state board of charities and the state board of health would have a general oversight over them. The 'yes' or 'no' to this question will affect a great many buildings that need ventilation as much as those included in the first list. And further, should not theaters, opera houses, and public assembly halls come under the same head? These latter must conform to the law regarding fire escapes, exits, fire protection, etc., also the drainage from plumbing systems, and the safe construction under

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the building law. Why, if necessary to protect the public from bad gases in defective drainage, is it not also necessary to protect them from dangerously vitiated air? I believe that the time is coming when this latter will be of equal importance with the other.

"Having determined the class of buildings we should ask for compulsory ventilation in, the next step to determine will be the amount of air per occupant per hour that the law should require as a minimum. To this we should add a requirement that the incoming air should be warmed during cold weather to a degree sufficient to prevent the body of the air in the rooms occupied from being cooled below the temperature of, say, 68 degrees F. The manner in which this is to be done will, of course, vary with each different method of warming the building.

"The third step will be to appoint the controlling body, who shall determine and approve all plans for work in these buildings. I would suggest that there be a state board of engineers of, say, three competent men, one of whom could be a qualified heating and ventilating engineer of known reputation and ability, the second, a qualified chemist, and the third, an architect or consulting engineer.

"The law passed should be mandatory, requiring plans for all future buildings of the character decided on to be first submitted to them for approval as to the sufficiency and method of ventilation. When they have passed the plans a certificate should be issued by them, stating this fact, and a copy of the plans and specifications filed among their records for future reference. These engineers should be paid a salary by the state commensurate with their ability. There should then be a body of men under their direction (whom I should call inspectors), whose business it will be to see that the plans and specifications are carried out and the results obtained, as demonstrated by tests. Copies of these tests and general report to be filed with the original plans and specifications.

"I would arrange that these plans and specifications can be examined, under proper direction, by the general public. The number and salary of these inspectors can be determined by the number of buildings in any state requiring their attention. They should be required to pass an examination before the board of engineers.

"The law should not only apply to new buildings to be erected, but should also extend to all buildings already in use, requiring them to be changed to meet the conditions within a given time, say, five years from the passage of the law.

"Your committee will also have to consider carefully the politics of the case. There is great jealousy between state and city officials.

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The officers of our larger cities resent the interference (as they call it) of state officials into city affairs. It might be well to have a separate board in cities of, say, 200,000 inhabitants and over. It will make places possibly they think, or at least give them a standing of their own—a sort of home rule spirit.

"In Pennsylvania, you no doubt know, we have a state board of charities and a state board of health. Other states probably have different arrangements. It looks to me as though it would be better to have a separate board of engineers, rather than to work through existing authorities, although, doubtless, to do so will incur their opposition.

"Lastly, in framing a law, it will be of the greatest importance to have the aid of a good legislative lawyer in drawing it up, and also the assistance of a prominent member of the legislature to introduce it, one with tact enough not to antagonize the existing powers that be, and one who is familiar with the game of politics as it is played in our state legislatures. Don't ask too much. We may get nothing, but be prepared to back strongly what we do ask for."

Rufus R. Wade:—"In answer to your request that I give you my ideas on the matter of compulsory legislation relating to ventilation of buildings, I would say that the present legislation on the subject in this state is the result of the broadening of sanitary laws which were applied to factories and workshops. I am of the opinion that legislation of this character, to be effective, must embrace factories, workshops, schools, and public buildings. To accomplish what has been done in this state, and to secure the results obtained, has required untiring effort and has been a laborious and oftentimes discouraging task. To educate the public concerning the correct principles of ventilation it has been necessary to stem the tide of indifference and arouse the sense of responsibility.

"It is a curious fact that these elementary laws of public health are not accepted without resistance. The inertia of popular indifference is an obstacle whose power it would not be easy to over-estimate. What has been done in this state can be done in others. The laws under which we act, and which are accepted by the public generally and are cheerfully complied with, will be found in the pamphlet herewith enclosed. I am gratified to learn that your association is about to commence a crusade in the interest of securing perfect sanitary conditions in your public school houses and other public buildings. But success demands ceaseless vigilance and the most persistent presentation of the facts gathered by daily observation. As you truthfully write, it is a broad subject and will require much time and labor. This department has established the rule that 30

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cubic feet of fresh air per minute shall be furnished each scholar during the school session. When plans are submitted to us showing methods of heating and ventilation, we require guarantees that results shall come fully up to the standard. In public buildings 15 cubic feet per minute, and this amount is the minimum. Our law is now working well and I shall not ask for further legislation on the subject."

Mr. Carpenter stated that accompanying the letter from chief of Massachusetts District Police Wade of Boston, was a small pamphlet, which probably many of the members had seen, in which several clauses were marked, and he asked the chair whether it would be well to read these.

The President:—I think you might read the clauses referred to.

Mr. Carpenter:—(Reading.)

Section 33. Every factory in which five or more persons are employed, and every factory, workshop, mercantile, or other establishment or office in which two or more children, young persons, or women are employed, shall be kept in a cleanly state and free from effluvia arising from any drain, privy, or other nuisance, and shall be provided, within reasonable access, with a sufficient number of water closets, earth closets, or privies for the reasonable use of the persons employed therein; and wherever two or more male persons and two or more female persons are employed as aforesaid together, a sufficient number of separate and distinct water closets, earth closets, or privies shall be provided for the use of each sex, and plainly so designated; and no person shall be allowed to use any such closet or privy assigned to persons of the other sex.

Sec. 37. Every factory in which five or more persons are employed, and every workshop in which five or more children, young persons, or women are employed, shall, while work is carried on therein, be so ventilated that the air shall not become so exhausted or impure as to be injurious to the health of the persons employed therein, and shall also be so ventilated as to render harmless, so far as is practicable, all gases, vapors, dust, or other impurities generated in the course of the manufacturing process or handicraft carried on therein, which may be injurious to health.

Sec. 38. If in a workshop or factory included in Section 37 of this act any process is carried on by which dust is generated and inhaled to an injurious extent by the persons employed therein, and it appears to an inspector of factories that such inhalation could be to a great extent prevented by the use of a fan or by other mechanical means, and that the same can be provided without incurring unreasonable expense, such inspector may direct a fan or other

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mechanical means of a proper construction to be provided within a reasonable time, and such fan or other mechanical means shall be so provided, maintained, and used.

Sec. 39. No criminal prosecution shall be instituted for any violation of the provisions of sections 37 and 38 of this act unless such employer shall have neglected for four weeks to make such changes in his factory or workshop as shall have been ordered by an inspector of factories, by a notice in writing, delivered to or received by such employer.

Sec. 40. Every public building and every schoolhouse shall be kept in a cleanly state, and free from effluvia arising from any drain, privy or other nuisance, and shall be provided with a sufficient number of proper water closets, earth closets, or privies for the reasonable use of the persons admitted to such public building, or of the pupils attending such schoolhouse.

Sec. 41. Every public building and every schoolhouse shall be ventilated in such a proper manner that the air shall not become so exhausted as to become injurious to the health of the persons present therein. The provisions of this section and the preceding section shall be enforced by the inspection department of the district police.

Sec. 42. Whenever it appears to an inspector of factories and public buildings that further and different sanitary provisions or means of ventilation are required in any public building or schoolhouse, in order to conform to the requirements of this act, and that the same can be provided without incurring unreasonable expense, such inspector may issue a written order to the proper person or authority directing such sanitary provisions or means of ventilation to be provided, and they shall thereupon be provided, in accordance with such order, by the public authority, corporation, or person having charge of, owning, or leasing such public building or schoolhouse.

Sec. 43. Any school committee, public officer, corporation, or person shall within four weeks after the receipt of an order from an inspector, as provided in the preceding section, provide the sanitary provisions or means of ventilation required thereby.

The President:—Gentlemen, you have heard the reading of the correspondence. I would ask the chairman of the committee what is the desire of the committee in regard to it; whether they prefer to hold the report open and get the opinion of the members present and later on present a complete report, with recommendations, or whether they consider what has been given us already as the report of the committee.

Mr. Mackay:—It would be a question as to whether we could fur-

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ther fill out the report without the assistance of one of the three other members of the committee. I think it is no longer possible that we shall have them at the meeting, and it would seem to me that you would either have to take this as a final report, or appoint some others to take the place of the three members of the committee who will not be present.

The President:—The other three are?—

Mr. Mackay:—Mr. Prentice, Mr. Harding, and Mr. Crane.

The President:—Mr. Harding, I understand, is in the West at the present time.

Mr. Mackay:—I am told that Mr. Prentice is in the city.

The President:—In that case it might be well to hold the report open until a majority of the committee get together to make a positive recommendation to accompany the report. I think that would be well if it meets with the sense of the meeting. If there is no objection on the part of the members present, we will receive the report as a partial report and defer any action until we get a majority of the committee to complete the report.

I would now call for the report of the committee on uniform contract and specifications. Mr. Quay, I see, is in the room and can tell us something about it.

Mr. D. M. Quay:—Mr. President, I have not any definite report prepared. I corresponded with all the members of the committee and received letters from them, and I had hoped to be able to call the committee together at this meeting. I do not think a majority of the committee are here, but possibly they will be. I should like to defer my report until I can find out whether we can have a meeting of the committee. If they do not come, then I will read you what I have, if that is satisfactory.

The President:—May I ask, Mr. Quay, if you expect a majority of your committee here. Have you any information as to that?

Mr. Quay:—I have no information as to that. The secretary probably has a list of the members of the committee and can tell whether they are likely to be here or not.

Secretary Hart:—I see by the report that Mr. Jellett, Mr. Quay, and Mr. Smith are on that committee.

The President:—Mr. Harding and Mr. Bates were afterwards added at the last annual meeting, and then I asked that some one else take my place. Is that correct, Mr. Quay?

Mr. Quay:—I did not understand that Mr. Jellett was excused from the committee and that the other two members were added.

The President:—As I have it in my notes, Mr. Quay (Chairman), Mr. Smith, Mr. Harding, Mr. Bates, and myself were the

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original committee. First of all the committee consisted of three, and there were two added—Mr. Harding and Mr. Bates.

Mr. Quay:—That is correct, I think.

The President:—If it meets with the sense of the meeting, we will defer the report of the committee on uniform contract and specifications until some later time in the meeting. I would like, however, the sense of the members present on this matter.

Mr. Quay:—I would like to ask the secretary if he has any information as to whether the other members of the committee are likely to be here or not?

Secretary Hart:—I have not. I think Mr. Smith will be here. I do not think Mr. Harding will be here. I have not heard from Mr. Bates lately. A little while ago he wrote me that he would be here probably, but I have not heard from him since.

The President:—Will some gentleman make a motion that the report of this committee be deferred until later in the meeting, so that we can take it up more fully?

Mr. Mackay:—I move, Mr. President, that the report be deferred until later in the meeting. (Motion carried.)

The President:—The next is the report of the committee on tests. Are there any members of that committee here? Major Light is the chairman. He is not here. I have a letter from him in which he expressed a doubt of getting here, but he thinks it is quite likely his son will be here. That committee is Major Light, Mr. Hunting, and Mr. Bates. I have not seen any of them here as yet. Major Light makes no report in the letter. He simply refers to the question of the uncertainty of his getting here. We will have to pass that.

The President:—The next in order is the appointment of the nominating committee, but by direction of the board of managers a note has been placed at the bottom of the programme fixing the time of the appointment of this committee for the afternoon, on the ground that a great many people from out of town get here late, and it would not be advisable to appoint a nominating committee until we have a full session; so that will be taken up at the assembling this afternoon. The next will be the reading of papers. If there is no further business to come before the meeting at the present time—no preferred business— we will take the papers up in the order in which they are given on the programme. There are some matters of business that will require to be taken up later under the head of new business. There is nothing that is now pending that could be attended to, and we will take up the first paper in the series—"Electric Heating," by W. S. Hadaway.

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Mr. Hadaway then presented his paper.

The President:—Gentlemen, the paper on electric heating is now open for the discussion of the members.

Mr. Wiltsie F. Wolfe:—I move, Mr. President, that a vote of thanks of the society be tendered to Mr. Hadaway for his very able paper. (Motion carried.)

The President:—The paper is open for discussion and we would like to hear from the members.

Mr. D. M. Quay:—I am not going to discuss the paper, but there is one point I wish to call attention to, and that is that Mr. Hadaway has dealt with facts. There is no guess work about it. He gives us the results of his experiments, which, I think, are very valuable. That is one thing which should be adhered to in our our papers and discussions. It is quite interesting to have a man give us facts that have been proved to be true.

The President:—Is there any further discussion? If not, there is one question that should be taken up now as to our hours of meeting and adjournment for each session, so that members can make engagements which will not conflict with the hours of meeting.

Mr. Barron:—It is understood, of course, Mr. President, that the discussion of this subject can be resumed at any time, with the consent of the meeting.

The President:—The intention is, I think, all through, that at any point of the programme, matters of interest connected with any of the papers can be brought up by members calling attention to it at the proper time. It is now 1 o'clock, and if we could fix an hour for our reassembling, I think it would be well to adjourn.

Mr. Barron:—I move, Mr. Chairman, that we adjourn until 2 o'clock.

The President:—There are one or two committees, Mr. Barron, that want to report when we reassemble. I would suggest that you make it a quarter after or half-past two, as we want to give our committees time.

Mr. Barron:—Make it a quarter after two.

The President:—I think that would be better.

The motion to adjourn until 2:15 was put and carried.

AFTERNOON SESSION.

The meeting was called to order at 3 P. M.

The President:—The secretary will first announce the result of the last vote for members sent out which has been passed upon by the council during the intermission.

Secretary Hart:—The result of the last vote is that Andrew Har-

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vey, Detroit, Mich.; John A. Connolly, New York; and Francis A. Williams, New York, have been elected members, and E. J. Brooks, Bridgeport, Conn., and Howard A. Lock, Philadelphia, Pa., have been elected juniors.

The President:—The next thing on the programme was made the special business for the opening of this session—the appointment of the nominating committee. If you will note the clause on the programme, it says the nominating committee is to be appointed this afternoon to present the names of candidates for office at the opening of the session to-morrow afternoon. I would appoint on that committee, which the rules require shall be five, B. Harold Carpenter, Thomas Barwick, J. J. Wilson, H. A. Joslin, and J. J. Blackmore. They will get together after the session this afternoon and report at the opening of the session to-morrow afternoon.

I would like to have the sense of the meeting on the question of taking up new business at this point of the programme before getting down to papers. There are one or two things left over from last year that were to be brought up at this meeting, and it would be a good time, it seems to me, to bring them up now, rather than interfere with the discussion of papers. If this is the sense of the meeting, I think these matters can be taken up and put through in a short time.

Mr. B. F. Stangland:—The board of managers suggest in their report that at least three members of the council be selected from one city or vicinity, in order that they should hold more frequent meetings. I move you, sir, that it is the sense of this meeting that the nominating committee shall nominate at least a majority of the council from one city, as that would facilitate the transaction of business by enabling them to get together and act without so much correspondence and delay, not only in papers, but in applications for membership. I put that in the form of a motion. (Seconded.)

The President:—Is there any discussion, or is there any member who would like to ask the reason for making this recommendation?

Mr. J. J. Blackmore:—As one of the nominating committee, there is a question I would like to ask, so that the thing can be embodied in this motion, if found necessary; that is, whether the nominating committee is expected to bring in a number of candidates for each office, or whether they are to nominate just the number that is called for. In the latter case, the nominating committee would practically be an electing committee. If, on the other hand, the nominating committee brings in a number, the ballots, when they are cast, might elect members from widely different constituencies. The point just occurred to me as to how to get over the

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difficulty. If the nominating committee nominates just the number of members for the council that our constitution requires, that would make the nominating committee an electing committee.

Mr. President:—I was going to say for your information, Mr. Blackmore, that the by-laws require that there shall be two candidates for each office. If there are five members of the council, it will require ten nominations.

Mr. Blackmore:—Then, that makes it very awkward for the nominating committee, because the members in balloting may ballot and elect a council contrary to the spirit of the motion. That is to say, if we select three from New York and vicinity and the rest from the country at large, those that are from the country at large might be elected and not one from the city, and it seems to me that the motion would place us in rather an awkward position.

Mr. Barron:—Mr. President, the motion is merely a suggestion, because the point of order was made that it would be unconstitutional to give any directions. It is merely a suggestion to the nominating committee.

Mr. W. M. Mackay:—It would seem to me that it would be an easy matter for the nominating committee to nominate three members from Boston, three from Chicago, three from New York, and perhaps three from Philadelphia; and as the secretary in his report offered it as a suggestion, and the board of managers offered it as a suggestion, it would seem to me we would have to leave it to the members as to who they should elect. It would seem to me that the work of the society would be apt to center on three members from one location, not necessarily New York, not necessarily Philadelphia, not necessarily Boston.

The President:—The motion as made by Mr. Stangland is that it is the sense of this meeting that the nominating committee, in making nominations for the council, should take into consideration the selection of a majority of the committee from some one city in order to facilitate the business of the society. (Motion carried.)

The President:—There was a motion made at the last annual meeting, to be brought up at this meeting, to elect the officers of this society in the manner now in use by the American Society of Mechanical Engineers. Mr. Secretary, you have the resolution which was introduced at that time.

The rules required that it should be introduced at one annual meeting and voted on at the next. I would say for the information of those present at the time the resolution was introduced that it was done to save time at our annual meeting, it being the sense of the members present, or at least a large number of them, at our last

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annual meeting that we could very materially shorten the business sessions and give more time to the discussion of papers and engineering questions for which we are here, and that the methods used by the American Society of Mechanical Engineers was to send a printed form with instructions how to vote, a list of candidates for the office as selected by the nominating committee, and then a printed form of envelope addressed to the teller of the election, the ballot being secret, and at the opening of the annual meeting announcement is made of the result of the vote. The election is taken out of the proceedings of the annual meeting, the record of the candidates for office being sent with the instructions to members for voting.

Secretary Hart (Reading from the report of the first annual meeting):—"Mr. Jellett:—I would move to amend Article VI of our constitution on annual meetings and election of officers, so as to have the nominations made by the nominating committee printed and sent to members and votes returned before the annual meeting in the general manner now in use by the American Society of Mechanical Engineers. This is to be brought up at our next annual meeting."

The President:—If there are any members of our society who are members of the Mechanical Engineers I think it would be interesting to have them explain this. Mr. Stangland, can you explain the present method of voting in the Mechanical Engineers' Society?

Mr. Stangland:—Well, I think no better than our president has. I think you explained it quite fully.

Secretary Hart read to the meeting the printed instructions for voting which are sent out with the ballots by the American Society of Mechanical Engineers.

Mr. Barron:—Mr. President, I am a little on the fence. I am in doubt whether the men who do not attend the meetings should decide who the officers shall be, or whether it should be left as it is now; that is, that those who attend should appoint the officers. That is really the essence of the question, to my mind. I would, therefore, move you, sir, that the consideration of this matter be delayed until later in this session. Then we can lay it over to another session if it is desirable.

Mr. Blackmore:—Does our constitution allow us to make a change at this session?

The President:—Yes, sir, the notice being given at the session before.

Mr. Blackmore:—Notice was given before?

The President:—Yes sir. Last year's proceedings are a part of our record.

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Mr. Blackmore:—I think that it would be a very desirable addition to our constitution, because last year we lost a great deal of time in the election of officers. I think the officers should be elected from the society at large and not by the members who are present. There are a great many members who are interested in the society and the workings of it who cannot always get here. Therefore, I think the method provided by the Society of Mechanical Engineers is quite adequate for ours, and as notice was given at our last session, I move that the article just read be incorporated in our constitution.

Mr. Stangland:—I would second that motion, Mr. President.

The President:—Gentlemen, it has been moved that the clause in our constitution covering the manner of electing officers in our society be changed to correspond with the general method employed by the American Society of Mechanical Engineers, which you have just heard read.

Mr. Mackay:—I should like to ask if that does away with the part of our constitution and by-laws which refers to the election of officers?

The President:—I should say it would take the place of it.

Mr. Mackay:—Or is this an addition merely for collecting the ballots, otherwise do we still proceed as we formerly did? There is another point that I would like to speak about, and that is where one member can vote three times for one man for one office. That does not seem right. I should want each member to be allowed to vote for one man once for one office, and if he did not care to vote for the other vice-presidents, say, that he refrain from voting for them, but let his vote only count for one. He pays one membership due and he should only vote for one candidate once. I think, apart from taking up the time of our meeting, that we cannot get up any better way of electing our officers than that laid down in the constitution and by-laws. This was gone over at length and different ways suggested, and the by-laws were adopted covering that ground, and it would seem to be out of place to blot them out for the purpose of following some other society's footsteps. I think that we should perhaps adopt some other way of collecting the ballots that would give us for other business the time that is taken up by that matter under our present system. I have no objection to a member who cannot attend or does not attend saying who shall be the officers of the society, but I do not think that we should wipe out what we have already done and what has been found to be all right.

Mr. Wiltsie F. Wolfe:—If the motion as made should prevail, could we have an election now? I ask that only for information.

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The President:—It would not affect the election until next year. The nominating committee being already appointed for this election, it would not affect the election this year.

Mr. Wolfe:—I supposed that that was the case, but I did not know whether the motion covered that or not, because if you had to send twenty ballots to all members not present the delay would make an election impossible at this time.

The President:—It cannot affect the present election. In answer to Mr. Mackay, I would say that I think his suggestion a good one. I am a member of another society where we have a method of voting similar to the Mechanical Engineers'. We simply cross off the names of those whom we do not wish elected, and we vote for only one candiate for each office. The blank itself and the endorsed envelope are very similar. It might be well to make the motion in such a way that we can get the sense of the meeting, covering the saving of time and meeting the objections raised.

Mr. D. M. Quay:—Could there not be a motion made to amend that part of the rule to which objection has been made, so that each member will only have one vote for each officer. I am very much in favor of adopting this rule. I do not think there is any objection to adopting a rule of any other society. The Mechanical Engineers' Society has had large experience and has seen fit, after having had this experience, to adopt this method of voting. The constitution and by-laws of our society were no doubt carefully prepared, but by experience we find that it is necessary to change them, and I think that this is a much better way of conducting the election than our present method, and I would move, as an amendment, that we adopt the same rule that the Mechanical Engineers' Society have, with the exception that each member have one vote for each officer. (Seconded.)

The President:—Gentlemen, you have heard the amendment to the original motion. Is there any discussion on the amendment? We will hear that now, or, if none is offered, we will take a vote on the amendment.

Mr. Wolfe:—Can the by-laws or constitution be amended by an amendment in the way of a notice given after the original notice was given: i. e., by an amendment to the amendment which was offered at our last annual meeting by which our by-laws or our constitution should be altered so as to conform, in one respect, to that of the Mechanical Engineers'? Now, can that be amended at this date and acted upon legally before a year from now?

The President:—The wording we have here is that the election

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shall be in the same general manner. It does not follow the details necessarily. The wording of the resolution was "In the same general manner now in use by the American Society of Mechanical Engineers," the idea being at that time to fit the conditions to meet our own wants. It was so worded that we could do that.

Mr. Mackay:—I would move you, as an amendment to the amendment, that we adopt that part of Mr. Jellett's motion which refers to the collection of ballots, allowing the present by-laws to remain as they are.

Mr. Quay:—I think that would be contrary to the motion, because, leaving out the "general manner," you are merely adopting one part of this resolution, not adopting the sense of it at all, and not adopting the motion as made at the last meeting.

Mr. Mackay:—As I understand, your motion was to do away with the delay in collecting the ballots at the meeting. I would be in favor of doing away with that delay and giving the time of the society to the reading of papers and the discussion of topics. I think that the mode of bringing in the nominations by the nominating committee, and all that sort of thing, is all right. Of course, there might have to be a time stated when the nominating committee should be appointed by the Chair; but it seems to me that it is only the collection of the ballots that we wish to dispense with here in the meeting, and I hope we will adopt that part of your motion which refers to this particular point.

Mr. Blackmore:—As the mover of the original motion, I have to confess that I was under a misapprehension. I find now that the proposed amendment to the constitution would substitute entirely the method of the American Society of Mechanical Engineers for our own method. I did not understand when I made the motion that it went as far as that. With the consent of my seconder, I beg to withdraw that motion, because I see that I made it without knowing all the facts.

The President:—It seems to me that you are all getting at the same thing, but are wandering around it.

Mr. Wolfe:—I think we all agree on one thing; we want to save time, and I would move as an amendment that the Chair appoint a committee, consisting of the original mover and two other gentlemen, to draft a resolution to meet the general sentiment of the meeting here and to present the same for a vote. (Seconded.)

The President:—As the first motion was withdrawn by the mover, will the seconder withdraw his second? Not hearing from the seconder, we will assume that the seconder is withdrawn. It has been moved and seconded that a committee of three be appointed

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to take this resolution and draft it in such a form as to meet the sense of the meeting by omitting the objectionable parts and meeting the conditions of our society's work.

Mr. Quay:—I do not think we understand yet what that resolution is, or what we want. Some one has said that the only thing we want to do is to save time. That is not the sense of the resolution at all. The saving of time is only one thing. The Mechanical Engineers have a method of electing officers. What that is is outlined there. Now it is not just merely the fact of saving time in collecting ballots that we are after—

Mr. Wolfe:—If I may interrupt you, I meant saving time here now.

Mr. Quay:—You wanted to get the sense of the meeting. This committee is to draft a resolution to conform to the sense of this meeting, and the point is to know what the sense of the meeting is—whether we want to adopt a method similar to that of the Mechanical Engineers or not. If we do, of course the committee can take up that point and frame something that would probably be more simple and more suitable.

Mr. Mackay:—I would like to ask Mr. Wolfe if there is any stated time for the committee to report?

Mr. Wolfe:—I take it that it would be subject to the order of the Chair—as soon as they conveniently could.

Mr. Mackay:—I mean, is it to be acted on at this meeting?

Mr. Wolfe:—Most certainly; it would have to be under the resolution proposed at the last annual meeting.

The President:—The committee would necessarily report before the end of this session, I should say. Is there any further discussion of this matter?

Mr. Wolfe's motion for the appointment of a committee was then put and carried.

The President:—I would appoint on that committee, Mr. Blackmore, Mr. Wolfe, and Mr. Quay, and I would ask that they report at the opening of our session to-morrow morning. Gentlemen, is there any further new business to come in at this point?

Mr. Quay:—I would like to ask what our constitution says about our meetings—if we are to have one a year or two. The question came up last year on the advisability of having a semi-annual meeting. I do not know whether our constitution provides for that or not.

The President:—There is no provision, I think, in the constitution for it. It was discussed at the meeting last year. Article VI of the constitution says: "The annual meeting of the society will

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be held in New York in January of each year, the date to be fixed by the board of managers 60 days in advance of the meeting." There is no reference to a semi-annual meeting there.

Secretary Hart:—In the by-laws it says: "In addition to the annual meeting there shall be a semi-annual meeting at places designated at the annual meeting."

Mr. Quay:—Last year we voted not to have any semi-annual meeting. I suppose it is proper this year to make a motion to have one. I move you, Mr. Chairman, that we decide to have a semi-annual meeting. But it says in the by-laws there shall be a semi-annual meeting, so if we carry out Article XII of the by-laws we will have one without any motion.

The President:—It was necessary last year to have a motion to dispense with it.

Mr. Quay:—If we do not have a motion to dispense with a meeting, we will have one then, will we not? I withdraw my motion then.

The President:—Is there any further new business? If not, I would make an announcement to the members present. A card has been left on my table stating that Mr. Thomas McNeil, who is in charge of the class in steam fitting of the New York Trade Schools invites the members of this convention to visit the steam and hot water classes there; that he will be there with his classes until 9:30 to-night. If any members of the society in town would like to see the school in operation, he will be very glad to show them through it. I think, in view of the kind invitation, that we should take some action and that those who have the spare time should go to see it.

Mr. Wolfe:—I would move, Mr. President, that the invitation be accepted and the thanks of this society extended to Mr. McNeil.

The motion was carried.

The President:—If there is no further no new business we will take up the papers.

Mr. Stangland:—I have something here which I would like to read to the members, and I trust it will be endorsed:

"It is the sense of this meeting of the society that no recommendation, endorsement, or approval shall be given to or made for any individual or for any engineering, mechanical, scientific, or literary production; but the opinion of the society may be expressed on such subjects as affect the public welfare, provided its opinion does not carry with it the interest of any individual."

I think it is important that this be considered. It might avoid some trouble in discussion, a possible law suit, or some hard feelings. Members can air their views here, but we do not endorse them.

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A member:—Will you kindly read that again?

Mr. Stangland read the resolution a second time and added:

In other words, we do not endorse any system, mechanical or otherwise, or any product or machinery, except as individuals.

Mr. J. J. Wilson:—I think the point is very well taken. It is a matter, I believe, concerning which there has been some agitation here before, and I hope that the members will thoroughly discuss this before it is voted on.

Mr. Quay:—Is this a resolution?

Mr. Stangland:—I read it for the edification of the members and I trust that it will be put in the form of a motion.

Mr. Quay:—I move you, Mr. Chairman, that this resolution be adopted and spread on our minutes. (Seconded.)

Mr. Wolf:—I would offer an amendment that it be made a part of the by-laws of the society.

Mr. Quay:—I accept that.

Mr. Stangland:—Anything that will make it more binding.

Mr. Barron:—I would like this thing brought out of the clouds. I confess I do not understand a word about it. I know of nothing that has been attempted to be endorsed here, and it seems to me that to put on our records a resolution so ambigiuous as that is simply absurd; it is childish to take men's time up listening to a resolution that means nothing. The phraseology is indistinct and leads to nowhere. It is practically in the clouds. If you pass a resolution let it be something definite that a common ordinary man can interpret and which it will not be necessary to submit to a judge in order to find out what it means.

The President:—I know of no engineering society which has not some such clause as this in its constitution or by-laws. The Franklin Institute Journal prints a notice that the Franklin Institute is not responsible for any article that appears in its journal. They publish it for general information, but do not become responsible. I am a member of the Engineers' Club of Philadelphia and we discuss all sorts of questions, but as a club we cannot be sued for expressing our opinions. Having such a by-law you can discuss a question as freely as you choose, but the society, as a society, is not responsible for your individual opinions. I know of no engineering society that has not some protection of this kind. I know of a case some time ago where the award of a prize was made at a mechanical exposition. One party felt aggrieved and sued the institute for the action of the committee of judges. They were thrown out of court, but it required, on the part of the officers of the institute, a lot of preparatory detail to present

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a proper defense and a great deal of expense for nothing. If such a clause as this had been in its constitution, and was known, the matter would never have gotten to a suit. I take it that the object in presenting this by-law is simply for the protection of the society from any questions that may arise. These things are very likely to come and do come when you least expect them. I think it does not restrict the members in any way. It does not interfere with any particular system or with any apparatus of any kind. It simply puts the society on record that they themselves are not responsible for the individual opinion of the members, and those opinions can be expressed as freely with this as a by-law. This is my interpretation of what has been suggested.

Mr. Blackmore:—If we do not pass a resolution like this, could the society be held legally responsible for any opinion of its members?

The President:—I cannot answer that. I am not a lawyer. But I think a case might be made against the society.

Mr. Blackmore:—I do not see myself how it could be possible. It seems to me absurd that this society should be held responsible for the opinions of its members; but if there is any doubt about that, by all means let us have it in such form that we cannot make a mistake.

Mr. Wolfe:—I look at it in this way—I am no lawyer—but I understand the gist of the motion to be as the president explains it. Now, as a matter of business, as a society, would we want to be indorsers, by adopting a resolution offered here and so becoming responsible as an indorser becomes responsible upon a note? If this society is what it ought to be and what it undoubtedly will be, it is a society whose opinions ought to carry weight with people interested in good warming, good ventilation, good engineering, and if this society's opinion, as printed and quoted, could be used as an endorsement of any man's opinion as expressed here—and we might vote as a matter of courtesy or not vote at all on a thing we did not alogether approve of—might we not, without some such motion as this, go on record as an indorser and so become responsible?

Mr. Mackay:—It seems to me, as we hold our meetings and publish our proceedings, those are not proceedings of the individual members, but the proceedings of the society and we, as a society, can be held responsible for running down any man's goods and that he has a good case against us, and that such a resolution as that should be on the by-laws of the society. The proceedings are not the proceedings of individual members, but the proceedings of the society.

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The President:—Gentlemen, is there any further discussion?

Mr. Blackmore:—This evidently requires and admits of a great deal of discussion. Each member that speaks brings up some other question. We may indorse a principle without indorsing a system. This would not prohibit us from doing that. This simply speaks of the members, but the opinion of the society may be expressed on such subjects. It is one of the elementary facts of our profession that no part of it, I might say, is reduced to actual data by which we can say that a thing shall be done a certain way and will produce certain results. It is very largely experimental, very largely conducted on precedent. Now, this society can do a great good by laying down certain standards to be followed. If we lay down a certain standard, some system may come nearer to that than another—it does not seem possible to me that we would be liable to an action for damages if we did that, nor yet do I see that a resolution like this would protect us from it. I think that we ought to protect ourselves by every possible means we can. Whether the reading of this resolution would do it or not, I am not quite sure. I think this is a matter that should receive greater consideration and should be referred to a committee before we take action upon it.

Mr. Quay:—Mr. Chairman, I do not understand that this resolution would affect any motion we might pass as a society, but our proceedings go out and are published and I find that they give an account of what every member says, or pretty nearly so. Now, I think this rule is to guard the society against what individuals express in the meeting. It is not going to do any harm and it is all we want as far as it goes. We cannot relieve ourselves as a society of responsibility for any motion that we might pass or any rule that we might adopt.

Mr. Wilson:—I can see very plainly how we could adopt the standard and at the same time not necessarily commend or adopt a system. Standards, of course, are very desirable, and those can be adopted without indorsing any particular system. The results are given there and the standards named, and the systems can act up to them.

The President:—If there is no further discussion we will take a vote on this question. All in favor of the motion as made by Mr. Quay and seconded by Mr. Stangland that the resolution read become a part of our by-laws will express their opinion by saying aye —opposed no. The motion was carried unanimously.

The President:—Gentlemen, if there is no further business we will take up the papers, and as Mr. Kramer is with us I think it would be well to take up his paper on "Forced Blast Warming with Furnaces."

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Mr. Quay:—At our last annual meeting I think a resolution was passed that the papers, instead of being read throughout, should be merely read in abstract. We all have copies of the papers, and I think it might save time and probably we could get as much out of the papers by taking them up in abstract rather than to read the entire paper.

Here Vice-President Mackay took the chair and President Jellett read Mr. Kramer's paper, as Mr. Kramer was indisposed.

The President:—The paper of Mr. Kramer is now open for discussion. It deals with a very interesting subject. I trust it will be fully discussed at the meeting.

A discussion by Mr. Henry B. Prather was read by the secretary, and a number of members participated in the discussion which followed.

Mr. Quay:—I move a vote of thanks to Mr. Kramer for his able paper.

The motion was seconded by Mr. Barron and carried.

Mr. Quay:—I move you, Mr. Chairman, that the other papers be discussed without reading.

The President:—I was going to say Mr. Quay, for your information, that Prof. Carpenter expects to be here to-morrow morning and Mr. Eistert will also be here to-morrow morning. It would be well to defer those two papers until the gentlemen who wrote them are here and can each present his experience in the discussion.

Mr. Wilson:—I wish to say that I think this discussion has been a very valuable one for this meeting; there are quite a number of people in the heating trade who handle possibly two or three of the systems which have been enumerated, and I have had it said to me on several occasions, especially referring to our last meeting, that so far as heating by hot air was concerned, it was entirely eliminated from our discussions, and that many who looked to the society for the elevation of the art of furnace heating have felt that it had not had any consideration. For that reason I think the paper has been of advantage to us, without mentioning other points.

The President:—I think that we should now arrange the question of the hours of meeting and also the hour at which we should adjourn.

Mr. Cary:—I would make the motion that the Chair be appointed a committee of one to fix hours for the meeting and for the adjournment. (Motion carried.)

The President:—I will fix the morning session at 10 to 1 o'clock and the afternoon session at 2:30 to 5:30.

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Mr. Cary:—I move that topical discussions be taken up for the balance of our time.

The President:—The first question on the list of topics is: "Judging from present standards, what is the ideal system of heating for moderate sized dwellings, taking into consideration satisfactory results in warming, economy in operation, ease of management, reliability under all conditions, and original cost of installation?"

Let me say in connection with these topics that the order in which they follow does not necessarily mean the order in which they shall be discussed. Any question in the list of topics can be taken up at any time when we have the time to discuss it. If any other topic is preferred a resolution to that effect is in order.

Mr. Cary:—I make the motion that we proceed with the topics in the order in which they are placed here, unless some special occasion arises; then a motion would be in order.

The President:—Unless there is a motion to the contrary, we will follow the programme.

After considerable discussion on this topic the president announced that it was 5:30 and said that if there was nothing further of special interest he would entertain a motion to adjourn.

The meeting was then adjourned until the following day.

MORNING SESSION, SECOND DAY, JAN. 22.

The meeting was called to order on Wednesday, January 22nd, at 10:35 A. M.

The President:—The first business this morning is, by resolution of yesterday, the report of the committee appointed to change the by-law governing the method of voting for our officers. Mr. Blackmore, Mr. Wolfe, and Mr. Quay were the committee. I do not see any of them present. The secretary has their report, I believe.

Secretary Hart read the following report:

Agreeable to the president's request your committee begs to submit the following as the amendment for Article 6 on the annual meeting and election of officers.

"The annual meeting of the society will be held in New York in January of each year, the date to be fixed by the board of managers 60 days in advance of the meeting. The chair will select a nominating committee consisting of five members for the next ensuing annual meeting whose duty it shall be to present to the secretary, within ten days after appointment of date of annual meeting, the names of two candidates for each position to be voted for, and these names will be placed on ballots and such ballots will be sent to each member with a request to vote for the candidate he favors and re-

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turn same to the secretary in time to be counted at the annual meeting.

"No member shall hold more than one office at the same time, except that the president and secretary shall be members of the board of managers.

"Any member entitled to vote may vote by retaining or changing the names on said list, leaving names not exceeding in number the officers to be elected and returning the list to the secretary—such ballot enclosed in two envelopes, the inner one to be blank and the outer one to be indorsed by the voter. No member or associate in arrears since the last annual meeting shall be allowed to vote until said arrears shall have been paid.

"The said blank envelopes shall be opened by tellers at the annual meeting and the person who shall have received the greatest number of votes for the several offices shall be declared elected."

Mr. Hugh J. Barron:—I move that the report be adopted as read, Mr. President: (Motion carried.)

The President:—If there is no further new business to come before the meeting at this time we will take up the papers in their order.

Mr. Mark Dean:—Did you say new business was in order?

The President:—Yes sir.

Mr. Dean:—There is a matter brought up in the president's address which I would like to hear discussed by the society, and in order to bring it before the members, I would move that the board of managers instruct the secretary to employ an assistant secretary, either for six months or a year, as the board of managers may direct and as our financial standing will permit. (Seconded.)

The President:—The matter before the meeting, then, will be on the motion made by Mr. Dean that the board of managers arrange for the employment of an assistant secretary, carrying out the suggestion made in the address yesterday. The matter is now open for the discussion of the members.

Secretary Hart:—Gentlemen, this matter, of course, is a very important one for this society on account of the extra amount of work which is bound to come sooner or later. If the society does not care to have a semi-annual meeting this next year, I think that the secretary can probably get along with his work all right. The amount of expense for an assistant secretary would be five or six hundred dollars, in all probability, and the society really ought to have about 200 members before it goes to that expense. A semi-annual meeting this year would mean papers to be published—probably seven or eight—and the cost of those papers would be con-

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siderable. Of course, they do not have to be printed in a book until the annual meeting, but the cost of a semi-annual meeting is a good deal, and I think whoever is secretary could probably get along all right if the society does not have any semi-annual meeting. I, myself, would rather not see that expense tacked on to the society at this time.

Mr. W. M. Mackay:—As I understand it, all our available fund is about $1,000. It would take about three or four hundred dollars for the proceedings and we have got to have funds on hand for other purposes. It would seem to me that it would be wiser at this time to leave the matter to the board of managers, and I would move, as an amendment to the motion, that the matter of employing an assistant to our secretary be left in the hands of the board of managers with power.

The amendment was accepted by Mr. Dean and seconded.

The President:—The matter as it stands now is the amendment made to the motion of Mr. Dean. The amendment is that the matter be left in the hands of the board of managers with power to act. Are you ready for the question, or is there any further discussion?

Mr. Dean:—I think that improves the motion very much. As I understood the sense of the meeting, yesterday, it was that we were to have a semi-annual meeting; putting it in this way, if we have a semi-annual meeting the board can employ an assistant secretary, and if we do not have a semi-annual meeting the employment of an assistant secretary will not be necessary.

The President:—The motion is before you that the employment of an assistant secretary be left in the hands of the board of managers with power to act. (Motion carried.)

The President:—If there is no further business, we will take up the papers. We have on the list Mr. Prather's paper on "Heating and Ventilating of Large Churches." Two papers have been read —the one on "Electric Heating" by W. S. Hadaway, and one on "Forced Blast Warming with Furnaces" by George W. Kramer. The others have not yet been touched, and unless there is a motion to the contrary, we will take them up in the order in which they appear on the programme. As Mr. Prather is absent, we will have to call for a volunteer to read his paper.

Secretary Hart then read Mr. Prather's paper, when the president announced that the paper was open for discussion. Several of the members participated in the discussion and the president announced that if there was no further discussion, the third paper, "A Draft and Blast Pressure Gauge," by Prof. Kinealy, would be taken up.

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The secretary then read Prof. Kinealy's paper.

The President:—We will take this matter up again when Prof. Carpenter brings his gauge this afternoon. If there is no further discussion on Prof. Kinealy's paper, we will take up the next on the list, which is Prof. Carpenter's paper on the "Methods of Insulating Underground Systems of Steam Piping."

Prof. Carpenter then read his paper, and it elicited much discussion, after which the meeting was adjourned to 2:30 P. M.

AFTERNOON SESSION, SECOND DAY, JAN. 22.

The meeting was called to order on Wednesday afternoon at 3 P. M.

The President:—The secretary will call the roll of members, so the we may be sure of a quorum before we proceed to the election.

The secretary called the roll and 24 members were found to be present.

The President:—I will ask Mr. Barron and Mr. Edgar to act as tellers of election. We will now call on the nominating committee for their report.

The secretary read the report of the committee on nominations as follows: For president, Prof. R. C. Carpenter, Ithaca, N. Y., and C. W. Newton, Baltimore, Md.; for first vice-president, Prof. J. H. Kinealy, St. Louis, Mo., and D. M. Quay, Chicago, Ill.; for second vice-president, Wiltsie F. Wolfe, Boston, Mass., and E. P. Bates, Syracuse, N. Y.; for third vice-president, Joseph A. Langdon, Pittsburg, Pa., and Frank W. Foster, Boston, Mass.; for secretary, L. H. Hart, New York, and J. A. Harding, Vineyard Haven, Mass.; for treasurer, J. A. Goodrich, New York, and Albert A. Cryer, New York; board of managers, D. M. Quay, Chicago, Ill., S. A. Jellett, Philadelphia, Pa., Hugh. J. Barron, New York, Henry Adams, Washington, D. C., T. J. Waters, Chicago, Ill., W. S. Hadaway, New York, W. M. Mackay, New York, Henry B. Prather, Buffalo, N. Y., Alfred A. Hunting, Boston, Mass., J. A. Harding, Vineyard Haven, Mass.; council, Albert A. Cary, New York, B. F. Stangland, New York, William McMannis, New York, A. A. Cryer, New York, J. J. Blackmore, New York, John A. Fish, Boston, Mass., M. C. Huyett, Chicago, Ill., N. S. Kellogg, Boston, Mass., John J. Hogan, Middletown, N. Y., G. I. Rockwood, Worcester, Mass.

The President:—Gentlemen, you have heard the nominations read. I think the proper proceeding is to take them up in their regular order, beginning with the office of president. The tellers will pass ballots around to the members. I will state for the information of those present that under our constitution only mem-

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bers are allowed to vote. Associate members and juniors, under the constitution, have no vote.

Mr. Wilson:—I make a motion that a recess of ten minutes be taken by the members so that they can discuss the matter before coming to a vote.

Mr. Mackay:—I second that motion and ask that the names of the members of the council and board of managers be placed on the blackboard, as was done last year.

The President:—It was moved that we take a recess of ten minutes and that the names of candidates be placed on the board, so that members may have opportunity for mature deliberation.

Mr. Cary:—I think the names of all the candidates had better be put on the board.

The motion was carried and a recess of ten minutes was taken. The secretary wrote on the blackboard the names of all the candidates. After the recess the president asked the members to vote for a president. Mr. Barron announced the result of the ballot for president to be as follows: Prof. R. C. Carpenter, 16; Mr. C. W. Newton, 1; Mr. W. M. Mackay, 10.

The President:—Gentlemen, you have heard the announcement of the vote. Prof. Carpenter having the majority of the votes is declared elected.

Mr. Mackay:—I move that the election of Prof. Carpenter be made unanimous. (Motion carried.)

Mr. Jellett:—Prof. Carpenter, I am very glad to introduce you to the members of the American Society of Heating and Ventilating Engineers as their new president.

Prof. Carpenter:—I think, Mr. President, that properly I should not take possession until next year. I thank the society very much for the honor conferred and will try to do my duty as far as may be, although I do not expect to do as much as my predecessors or as your predecessor.

Mr. Jellett then resigned the chair to Prof. Carpenter.

The President:—It is now in order to vote for vice-president.

Mr. Quay:—If it is in order I would like to ask that the name of Mr. C. W. Newton be substituted for mine as first vice-president. I think it would be a good thing for the society to elect him as first vice-president.

Mr. Wilson:—It would be unwise to make any substitution. Mr. Quay has taken an active interest in everything pertaining to the society and I would ask him to allow his name to stand.

The President:—Please prepare your votes for first vice-president and the second and third—three separate ballots.

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The meeting then balloted for vice-presidents.

The President:—While the tellers are counting these ballots you may prepare your votes for secretary and treasurer.

Mr. Barron announced the result of the ballot for first vice-president to be as follows: D. M. Quay, 20; J. H. Kinealy, 7.

The President:—D. M. Quay having 20 votes and J. H. Kinealy 7, it would seem that Mr. Quay is elected.

Mr. Stangland:—I move that Mr. Quay's vote be made unanimous. (Motion carried.)

Mr. Barron:—I wish to announce that there are two votes for C. W. Newton.

The President:—They should be included in the report but do not affect the result. The tellers are prepared to announce the result for second vice-president.

Mr. Barron announced the result of the ballot for second vice-president to be as follows: E. P. Bates, 14; W. F. Wolfe, 12.

Mr. Wolfe:—I move that it be made unanimous. (Motion carried.)

The President:—Mr. Bates is elected unanimously. The tellers are ready to announce the result for third vice-president.

Mr. Barron:—Mr. F. W. Foster received 14 votes; Mr. Joseph A. Langdon, 9; Mr. James A. Taylor, 1; Mr. W. M. Mackay, 1.

The President:—Mr. Foster seems to have clearly a majority of all the votes cast. If there is no objection I declare that the votes show Mr. Foster elected.

Mr. Mackay:—Will it not be necessary to put another name on the board of managers to take the place of Mr. Quay who is to be one of the vice-presidents?

Mr. Wolfe's name was put on the blackboard for the board of managers.

The President:—The tellers will now prepare to collect the ballots for secretary and treasurer.

Mr. Wolfe:—Gentlemen, I am very much obliged to you. But the other nomination was made without my knowledge and had you been kind enough to elect me to the office I could not have taken it, because, as it is, I have more than I can do, and I do not want to assume a position when I cannot do justice to it. I did have the position of vice-president one year and I was unable to do you or myself justice by any actual work.

The President:—While the tellers are counting the votes for secretary and treasurer, will you please prepare your votes for the board of managers—five names?

Mr. Barron announced the result of the ballot for secretary to be as follows: L. H. Hart, 26; James A. Harding, 1.

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The President:—You hear the announcement, gentlemen. Mr. Hart has received the majority.

A Member:—I move that it be made unanimous.

A Member:—I move that the thanks of the association be tendered to Mr. Hart for his very able services to the society.

The President:—I think we had better make that a separate motion.

The motion to make Mr. Hart's election unanimous, was put and carried. The motion that Mr. Hart receive the thanks of the association was carried by a standing vote. The president requested the mover of the resolution to put it in writing.

Mr. Barron announced the result of the ballot for treasurer to be as follows: J. A. Goodrich, 24; A. A. Cryer, 4.

Mr. B. H. Carpenter:—I move that it be declared unanimous. (Motion carried.)

The President:—Has every one voted for the board of managers? If so, I declare the ballot closed. Please prepare your votes for members of the council. It was voted at the meeting yesterday that it was the sense of the society that three of the members of the council should live in New York, or some other one city, for convenience of getting together.

Mr. Mackay:—It was not the intention to mention New York, but that three of the council be from one city, where they could get together.

The President:—The names of the nominees are written on the board. As the tellers may be some time in counting the votes for the board of managers and the council, I would suggest that the topics of discussion, which I think are the next thing on the programme, be taken up, and then we can stop at any time and finish the voting, or listen to the report of the tellers.

Mr. Jellett:—Could not the tellers first collect the ballots for council and count them all? Then the members would not have to take that matter up again.

The President:—It is suggested that the votes for council be collected and the returns given later. I think that would be a good plan, so please prepare your votes for members of the council.

The tellers collected the ballots for members of the council.

The President:—The next order of business, I see by the programme, is new business. Is there any new business to be brought up before the society before taking up topical discussions?

Mr. Wolfe:—Yesterday it occurred to me that possibly we did not give enough attention to the matter of holding a semi-annual meeting. I believe that such a thing is provided for in our by-laws.

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If the business men here will stop to think, they must know that the holding of these meetings entails considerable expense, and it is a question in my mind if we are quite strong enough yet to bear the expense of two meetings a year. I simply offer this as a suggestion but I hope the members will think of it.

Mr. Cary:—I must say, Mr. President, that I am quite in harmony with Mr. Wolfe's ideas on this subject. I believe we have had three meetings now. Each one has been I think, more successful than its predecessor. I believe we have 107 members now, and I find that 54 have attended this meeting, or about half the membership. Considering the territory over which they are distributed, that makes this a very successful meeting. I think we are still a little too young to attempt a semi-annual meeting. This meeting is successful; our other meetings have been successful, and should we attempt a meeting that would not be successful I think it would take a long time to recover from it. I think we should go on for a little while until our membership increases, so that we will get an attendance of perhaps a hundred, and it looks as though that time is very near; and then I think the matter of semi-annual meetings should be considered more seriously. But to risk the danger of an unsuccessful meeting I think it hardly worth while. I must say I have not the temerity to go into it and sanction it. I believe a semi-annual meeting is required by our by-laws, and I would offer a motion, which I believe is in order, that the semi-annual meeting be omitted this year and that the next meeting be an annual meeting.

Mr. Jellett:—I second that motion. I think the reasons are good.

The President:—You hear the motion to omit the semi-annual meeting for the ensuing year. The question is now before you for discussion.

Mr. Quay:—Our by-laws say that the annual meeting shall be held in New York. It is not because I do not live in New York that I think it wise to have a semi-annual meeting. There are very few people here from any of the Western cities. I think that if we had a semi-annual meeting in some of the other cities we could thereby awaken greater interest than by having all our meetings in New York. There is another reason—our society is new and there are lots of questions coming up. Quite a number have been considered since our last annual meeting and I believe we could have done more work—our committees would have done more work—if we had had a semi-annual meeting. A year is a good while to wait to have a decision on an important question. The committee on uniform contract and specifications have not done very much, but I think we had a report nearer ready

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six months ago than we have now. The trouble is we put things off until a short time before the meeting. Of course, the point is well taken that if we had a semi-annual meeting which was not a success it would be worse than not to have one. But I believe we could get more interest from the members and get more members from the other cities if we were to have a semi-annual meeting and have it in some other city. I do not think the Mechanical Engineers' semi-annual meetings have been a failure at all. I am not a member of that society, but from the reports I have seen they have been successful. This is an older and much larger society, and there is no reason why we should not follow in their footsteps and learn from their experience.

Mr. Cary:—The Mechanical Engineers have a very large membership, and if you take the percentage of members who attend their meetings—and I do not see why a larger percentage of our membership should attend our meetings—it would give us a pretty small meeting I am afraid. Our meetings have been very successful, increasing each time. As I said before, I do not think that we are large enough to branch out and try to take in too much. I think that by going slowly a little while we will come out all right with our semi-annual meetings and create interest in other sections of the country, although I think we are doing that now. I think that we are growing slowly and in a healthy way, and I do not think there is any necessity for holding semi-annual meetings somewhere else for the sake of increasing interest. I think there is a great deal of interest now. I do not say but what there could be more, but I think the society is in a very healthy condition, and I think we had better leave experimenting alone until we are a little stronger and can stand it better.

Mr. Wolfe:—There is one other side of the question; you might call it the bread and butter side. At this season of the year, of course many of us can as well be here as not. Building is not going on, the weather prevents work on buildings, and we are in a measure idle. If we had a semi-annual meeting it would be probably some time between the first of June and the first of August, and I think most of our members then do not have much time to spare. While I would like to get to the meeting, I am very much inclined to think that I could not go. I have never been able to find a week in the summer time when I could take a vacation. There is that side to look at, too; and then, as Mr. Cary says, better no meeting at all than a poor one.

Mr. Mackay:—I would say, Mr. President, that while it was decided not to have a summer meeting, I found a large number of

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members in Philadelphia last June and we had an informal meeting. It also got the committees together and they were able to move in the direction of work. Of course we could save money by not having this meeting, or the meetings we have had, but I do not think we should look altogether to saving money. If we could have a summer meeting I think it would be a good thing. There are a good many heating and ventilating engineers outside of the society, and if, as Mr. Quay says, by holding a meeting in some of the Western cities, while some have said it was not right to lower the dignity of the society by looking for members, I do not think it would hurt the standing of the society to get in some good men that are out, and if a meeting in the West or other section of the country will strengthen the society and get in some good material that is on the outside, it would be a present and a lasting benefit to the society.

Mr. Wolfe:—Perhaps the treasurer can answer my question best. I fully appreciate the fact that a good structure pays if you have got the money to put it up; but there are certain expenses involved in these meetings, with our present membership and the known income that will come from them. Are our treasurer and secretary and president—whoever calls the meeting—justified in assuming the expense when they possibly do not know that they will have the money to pay the expenses? In other words, how many men here are ready to stand an assessment in case there is not enough to pay the expense?

Mr. Quay:—It is pretty easy for New York, Philadelphia, and Boston men to attend a meeting in New York. It is not so easy for them to attend a meeting in Chicago or some place at a distance away, but they ought to consider the other side. It is probably easy for engineers in Detroit and St. Louis and cities around there to attend a meeting in Chicago, but not so easy to attend one here. We have quite a number of members that are never at our meetings—bright men, too.

Mr. Wolfe:—I do not think that Mr. Quay possibly understood the drift of what I said and what others have said. What I said, and what I understood the other gentlemen to say, does not eliminate the feature of a semi-annual meeting. It is simply the question of the expediency of holding a semi-annual meeting this year. That is the point which I raised. I believe that a semi-annual meeting is really a good thing. I have been in associations years back where the annual meeting came in the beginning of the year, when we confined ourselves strictly to business. The semi-annual meeting would be at Niagara Falls or possibly at New York, so as to be convenient to Coney Island, or some other places of that kind, and

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we became better acquainted at our semi-annual meetings, and it brought about a more friendly spirit and better fellowship than the annual meeting ever brought about. I am strongly in favor of the semi-annual meeting when we can afford it.

The President:—A memorandum has just been handed to me from the treasurer, showing the balance now on hand to be something over $373. That may be an item of interest.

Secretary Hart:—That is a very good item as it stands, but we have already incurred a matter of $143 for engraving. No bill has come in for these papers yet. They are set up in advance and a certain rate is agreed upon. The official stenographer's services will probably amount to over $200, and then the transactions are printed and put in book form. The whole thing will cost us between $400 and $500. We can soon eat up all the surplus we have and the balance will be on the other side for a little while. I should like very much to see this semi-annual meeting deferred one year more. I sympathize with our friend Mr. Quay very much. I would like to see a semi-annual meeting. I would like to see it in Chicago. I believe it would add a great many members to our society, but in my judgment it would not be a good thing this year.

The President:—I would also say that I have attended several meetings of the American Society of Mechanical Engineers. I think their best attendance at their spring meeting has been less than ten per cent of their membership, whereas in their winter and fall meetings they have usually about double that percentage. They have had two meetings in New York city where they have had over 400 members present. I think they never have had over half that number present, and usually not as many as that, at their spring meetings.

Mr. Cary:—To go back to Mr. Quay's remarks, I do not think that we should look at this in a selfish way at all, but should go in for the good of the society, and it may seem as though my being a New Yorker I would find it very nice to have the meetings near by; but to tell the truth it is very hard to get to the New York meetings. I can attend the out-of-town meetings and enjoy them better. I do not think that we are going around with our hat in our hand to meet our expenses. We may have to do that if we attempt a semi-annual meeting. I think we have got to a healthy state where we are meeting our expenses. We may not have very much over. There may be a balance on the wrong side of the book for a little while, but that is all evened up in time. That has been proved to be the case in times gone by. We have not had any assessments, and I do not think that with the slim balance and with the word that just came from our secretary —

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Mr. Quay:—I withdraw my objection in order to get this thing settled.

Mr. Cary:—I do not think that we want to attempt a semi-annual meeting, but I do not speak as a New Yorker in a selfish way, wanting to see these meetings in the East. I want to see them in the West. But as to this matter of drumming for new membership—take, as an example in this city, the Union League Club, which has a long list of names, and it takes about four years to get into that club. It is a club that stands head and shoulders above all other clubs. If a person belongs to the Union League Club, he has a name, because it is conservative and is not looking for or trying to drum up members. I think we should stand in the same position as far as we can. We are meeting our expenses now. I do not think we want to give chromos to please people in certain sections of the country to try to get the membership increased. I think if we grow gradually from this time our standing will be much better and the society be much better off, and we will have a much better class of membership.

The President:—The question is called for. Those in favor of postponing the semi-annual meeting for one year will signify by saying aye. (Motion carried.)

The President:—The tellers are now ready to report on the vote for the board of managers. The first five names read on the list are those elected.

Mr. Barron announced the result of the ballot for the board of managers as follows: Stewart A. Jellett, 23; W. M. Mackay, 19; Wiltsie F. Wolfe, 18; Hugh J. Barron, 16; W. S. Hadaway, 15; Henry Adams, 14; James A. Harding, 12; H. B. Prather, 7; T. J. Waters, 3; D. M. Quay, 1; Alfred A. Hunting, 0.

The President:—Those elected then, in accordance with the rules of the society, are, Stewart A. Jellett, W. M. Mackay, W. F. Wolfe, H. J. Barron, and W. S. Hadaway. Those gentlemen are declared elected to the board of managers. If there is no more new business to be presented, we will take up the next order of business in the programme, which is topic No. 2: "What is the best method of ventilation for office buildings and those having comparatively few occupants?" It is suggested that Mr. Jellett open the discussion.

This topic was then discussed by various members.

The President:—The request is made that the vote for council be announced. A. A. Cary received 24 votes; A. A. Cryer, 19; B. F. Stangland, 17; J. J. Blackmore, 16; William McMannis, 15; N. S. Kellogg, 5; John A. Fish, 10; M. C. Huyett, 7; John J. Hogan 5; G. I. Rockwood, 4. Those elected are A. A. Cary, A. A. Cryer, B. F. Stangland, J. J. Blackmore, and William McMannis.

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The President:—If there is no further discussion on topic No. 2, we will pass to the next, which is: "What are the relative merits of the overhead system, the usual 2-pipe method, and the single pipe main with 2-pipe risers in hot water heating?"

After some discussion on this topic Mr. Quay took the chair at the request of the president.

The Chairman:—There was a little unfinished discussion on Prof. Kinealy's paper, which Prof. Carpenter would like to conclude.

On finishing his remarks Prof. Carpenter resumed the chair.

Mr. Stewart A. Jellett:—If not out of order, there is a matter that I think is of particular interest to our members in which we would do honor to ourselves, and that is this: In section 5 of article 2 on membership we provide for honorary members. As yet we have never elected an honorary member, but I wish to have a vote now on a name proposed by our council, if it is in order and meets with the sense of the meeting. The gentleman proposed for honorary membership is Dr. J. S. Billings, a man who is probably better known in connection with the science of heating and ventilation and matters kindred to it than almost any one in this country. He has made a special study of it for years. He was invited to join our society originally as an active member, but he is not eligible under our rules for active membership, never having been strictly a heating and ventilating engineer. He is the author of a work on ventilation that is well known. He was also the adviser, in connection with the Johns Hopkins University, in Baltimore, in the installation of one of the most complete systems of heating, ventilation, and sanitation in this country. He is the librarian of what is probably the finest medical library in the world and is now coming to New York to take charge of the combination of libraries here—the Tilden, the Lenox, and the Astor. I believe it would be an honor to the society to have Dr. Billings elected an honorary member, and I move that he be so elected, if it meets the sense of the meeting.

Mr. Cary:—I second the motion.

Mr. Fish:—I second the motion. I can only testify my cordial concurrence in what Mr. Jellett has said. I know Dr. Billings quite well, and I think he would be quite an acquisition to this society as an honorary member.

The motion to elect Dr. Billings an honorary member of the society was unanimously carried.

The President:—We have some little time yet before the regular hour for adjournment. I am very much afraid that I broke off the discussion on topic No. 3. Is there anything more to be said regarding it?

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There was some further discussion, when the president said: I would just say, as a point of order, that the time which was allotted to this session has now expired, and it would seem to me entirely proper to postpone this until the next session. I think there is a good deal to be done in the room after we adjourn.

MORNING SESSION, THIRD DAY, JAN. 23.

The meeting was called to order at 9:40 A. M. on Thursday.

Mr. Jellett:—Mr. President, the next topic will be No. 4, but that has been pretty thoroughly gone over in Mr. Kramer's paper. I think it might be well to take up the next one. It would prove of more general interest, I think.

The President:—Topic No. 5 is: "Which is the better practice in a system of hot water warming combining both direct and indirect radiation—to supply all from the same system of mains or separate mains to direct and indirect radiators." I would suggest in connection with this discussion that, as there are a large number of topics, the speaking be as much to the point as possible in order to cover a large portion of the topics. Will some one open the discussion on this subject?

The discussion on this topic was followed by consideration of topics 6 to 13 inclusive.

The President:—It is suggested now that we take up the regular programme.

Mr. Jellett:—I would move, sir, that we proceed with the reading of papers and postpone any business we may have until the opening of the afternoon session. I think there are some committee reports to come in at that time and we can facilitate the work by bringing it all together and wind it up at that time. I move therefore that we take up Mr. Eisert's paper on the cooling of closed rooms.

The discussion following the reading of this paper was participated in by several members, when the President said, "If there is no further discussion on this paper we will take up the next paper on the list—No. 7."

Mr. Hugh J. Barron:—The occasion for writing this paper was that I knew a steam fitter some time ago who put an 8-inch valve on his job where another valve was specified. This valve was in charge of colored men and in turning it on it exploded and killed the two men in charge of it. Whenever I have noticed in the newspapers anything about the explosion of a steam pipe I have cut it out and in nine cases out of ten I find it is the steam fitting that exploded and not the pipe. On an average I think that there are killed in this country and Great Britain 52 people a year by explosions of steam fittings.

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Mr. Barron then read his paper on "Screwed Fittings for High Pressure."

This paper elicited considerable discussion.

The President:—Mr. McKeever has something to present to the society, and I think he might present it now.

Mr. McKeever presented some remarks under the title "Food for Thought."

The President:—Topical discussions are now in order. This morning we passed over several topics of discussion, some of which can now be taken up. I think these topics of discussion which are not taken up and disposed of had better be retained on the programme another year. The next topic is No. 14: "Is the use of the steam loop for returning condensation from heating surfaces located below the water line of boilers of value, and can its field of usefulness be extended?"

After discussing various topics the meeting was adjourned until 2:30 P. M.

AFTERNOON SESSION, THIRD DAY.

The meeting was called to order on Thursday afternoon at 3 P. M.

The secretary called the roll and it was found that 16 members were present.

The President:—There is a sufficient number for a quorum. We will now proceed to take up business which has been laid over. The first I think we have is the report of certain standing committees, and the first committee on the list is the committee on standards, Mr. H. J. Barron, chairman.

Mr. Jellett:—I think the only committee that did not report was the committee on uniform contract and specification.

The President:—Of that committee Mr. Quay is chairman.

Mr. Quay:—Mr. Chairman, we have not a complete report to make. We have corresponded quite a good deal and have obtained the ideas of most of the committee—at least some ideas from them—with regard to this question, and I think it would be well to appoint a new committee to take up this work where we have left off and bring in a full report at the next meeting. If it is in order I would like to suggest that Mr. Jellett should be chairman of the committee in my place. I cannot stay but a short time and I will turn over this report to Mr. Jellett with the correspondence.

The President:—I understand this same subject of uniform contract and specifications is under consideration by various other kindred societies. They are all interested in getting a good con-

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tract and a good form of specification. I would suggest that, if it is possible, our committee co-operate with these other committees, because it seems to me that it would be much better if one standard could be adopted by all the parties interested. That thing may not be possible.

Mr. Quay:—I would like to state that our committee was instructed to confer with the Master Steam and Hot Water Fitters' Association, which we did, but their report had gone in and their uniform contract had been adopted by their association before we were able to do anything with it. They have adopted a uniform contract as an association, and I think it would be well to ask this committee to confer with them and other engineering societies. It is a very important thing, and the more views that can be obtained from different standpoints the more helpful will it be in framing a proper contract and specification.

Mr. Wolfe:—I would like, if I am in order, to tell a little of our experience in respect to a very essential part of the contract. I wish that everybody had the same thing. Our work has been very largely municipal work. The terms of payment of our contracts are specifically described—a certain percentage to be received on the delivery of the apparatus in the building and a certain percentage as the work proceeds, etc., and the party of the second part, which is the municipal corporation, agrees to pay the contract at those times. Almost always when we go to them with our bill they say, "That bill should have been presented on the 3rd of the month and then it could have been acted upon on the 16th." In other words, they utterly disregard the fact that they have signed a contract to pay us our money at certain times. Cities and towns have no credit to lose; you can sue them and they don't care a rap. That sort of thing has come to be not only unsatisfactory but decidedly disagreeable. I talked the matter over with our people and we hit upon a scheme that seemed right, but they advised me to consult certain lawyers as to the legal aspect of the affair. We go on to say, after enumerating what we propose to supply and do and specifying as to the terms of payment, "In consideration that the moneys have been paid by the parties of the second part to the parties of the first part, the parties of the first part agree and guarantee to perform and do so and so." In other words, if they do not pay us the money the day the contract calls for it (we do not have to send any bill), and we want to be disagreeable about it, we do not guarantee anything. We simply say, "You broke your contract and you cannot hold us to our guarantee." I submitted that to three good lawyers, in my opinion as good as there are in the country, and paid them for

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their opinions, and each one of them advised me, without knowing anything of what the other had said, that that was good law—that was a consideration for a consideration; that is, for the convenience of having the money at the time that they agreed to pay it to us we were willing to guarantee the results, and they had agreed to pay the money at a certain time as a part payment for that guarantee which we gave. It was something for something and consequently it was a good contract, and if they didn't pay it on the day they agreed we were relieved from all responsibility on the contract. As to the working of that, it has worked all right. There was one town in particular when, during the squeeze of 1893, we required quick money. I went to the officer of the municipality who had charge of the matter and he said, "We are very sorry but we haven't a dollar in the treasury and our city charter forbids us to borrow money and pay more than 6 per cent interest. We cannot borrow money now without paying 12 to 15 per cent. Consequently, until this flurry is over, I cannot pay you." I said, "That is all right You better call your committee together to-night. The money is past due. If you are ready to give us a check to-morrow morning we are ready to assume all guarantees. If you do not pay us the money to-morrow morning, you can pay when you get ready, but we don't guarantee anything." We got the money the next morning. The committee did not want to take the responsibility of not having any guarantee. Now they do not raise any objection to that. If they look at it carefully, it doesn't mean anything, because we say in the former part of the contract that the party of the second part agrees to pay forty per cent on the delivery of the apparatus, forty per cent on the completion, or whatever the terms are. They have agreed to that and they are only agreeing twice to what they agreed once, and we get our money and I think it is a pretty good and easy way of getting it.

Mr. Jellett:—I would say for the information of the gentlemen present that the committee have had copies of contracts, copies of specifications, and a great deal of data collected. Further, I would say that any man present who has a form of contract that he uses, or a special form of uniform conditions accompanying a specification we would like him to send it to the committee. Each man here probably has had a different form of contract to deal with or several forms of contracts. If we could send them to the committee we would be very glad to receive them. We have already received a number and we are searching for all the information on that subject that we can possibly get.

The President:—The committee on standards have already made

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their report. That committee consists of Mr. H. J. Barron, Mr. William McMannis, and Mr. Kinealy, and it seems to me that the committee had better be continued, as their work is unfinished. I would therefore appoint for the coming year the same gentlemen as the members of that committee—Mr. H. J. Barron, chairman, Mr. William McMannis, and Mr. J. H. Kinealy.

Mr. Barron:—Prof. Kinealy is chairman of that committee. Mr. McMannis and I agreed that he should be chairman. Prof. Kinealy has done all the work and the work is completely finished. Our committee is of course quite different from the contract committee. We made our report and that ends our work. I would very much like to be discharged. Prof. Kinealy investigated the whole thing and now I think it is for this society to adopt that standard or not to adopt it just as they see fit. So far as the committee doing any further work is concerned it would be impossible.

Mr. Cary:—Mr. Chairman, Mr. Barron spoke about our society adopting the report of the committee adopting certain standards. I think this is rather treacherous ground for us to get on. Let our committees have these standards and put them before the society and let the matter rest just where it is. So far as adopting them, that has already been gone through pretty well in the Society of Mechanical Engineers. They appoint committees to look into these various matters but are very careful not to endorse any of the committees' reports. I think that Prof. Carpenter will appreciate that. Let these reports be the reports of our committees and let them stand there rather than be standards adopted by our society. That is not done by any of the other engineering societies, and I think that as they are a good deal older than our society and have had a great deal more experience we had better do as they do and follow their methods.

Mr. Mackay:—There is a committee on compulsory legislation, and the constitution says that one of the objects of the society is to favor legislation compelling the ventilation of all public buildings in accordance with the standard of this society. If there is no standard it would be better to discharge the legislative committee, and as one of the legislative committee I would say that we cannot do very much more until there is a standard adopted by the society.

Mr. Cary:—The society in appointing committees is supposed to select men who are competent to deal with these matters. They are supposed to be men the most familiar with the different details to be considered in the society, and seeing that they have been selected by the society as a committee I do not see why it does not carry

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just as much weight with it. But we are very apt to change our opinion as time goes on. One committee will be appointed that will follow the conditions of to-day. Two or three years from now something new comes and another committee is appointed to reconsider the matter and then they will put their report forward and that, being the latest report, will be as good as an accepted standard of the society as a whole. But the legislative committee might take the standard proposed by this other committee and go ahead with it just as well as though it had been accepted as a standard by this society as a whole. I see no good reason why they cannot do that.

The President:—It would seem to the president, and he is inclined to rule, that we are to keep a standing committee for the especial purpose of considering this question, as one of the objects of the society is stated to be "to establish a clearly defined minimum standard of heating and ventilation for all classes of buildings." I think it would be clearly a mistake to adopt any single year's work of the committee as a standard. What I do think is that we should keep a committee for this purpose and should have a report every year, and possibly at some time we may come to a point when we may be willing to adopt some standard, and that I think is clearly our duty. But to adopt any standard from the work that has been done will lead us, in two years, into difficulty.

Mr. Mackay:—I did not believe that it would be policy or that it would be possible to establish a permanent standard. We could establish a standard that could be changed from year to year, and in my judgment the present standard handed in by the committee is, if anything, too high for present uses.

Mr. Barron:—Mr. President, I am sorry to disagree with you, but the men who framed this constitution and those who adopted it had clearly in their mind the establishment, as soon as possible, of a minimum standard of heating and ventilation. Prof. Kinealy has simply taken the average practice of this country, and he asks the society, or we ask the society, to establish that as a minimum standard, if they so choose. But I think it is very clearly fixed here that we should define a minimum standard of ventilation and heating, particularly ventilation. That was the spirit of this constitution and it is the letter of it, and I do not think keeping a permanent committee is carrying out the constitution; it looks to me as if it was evading the responsibility for that work.

Mr. Cary:—I think that this matter has been pretty well discussed before other engineering societies. I think they are all agreed on this one point. I do not think that we are old enough—

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The President:—I do not think you are talking to the point at all The point is this statement in regard to the constitution. It is not the question of what we are going to do about this matter but the question is of obeying this constitution. I do not see how that matter of expediency has anything to do with it at all.

Mr. Cary:—I agree with you. I was merely defining my reasons leading up to that very point. I think that your suggestion meets what I intended to say, and I think, following such a precedent, it would be wise to meet that condition in the manner you suggest. I think that all present must be able by this time to get a clear conception of the matter, and I should be very glad to have the voice of those present in regard to their views on the subject.

Mr. Wolfe:—I believe that the ruling of the chair must be right as to the provision of the constitution in regard to a standing committee. If we accept the report of the committee and discharge them we will brand ourselves at once as being non-progressive. This society has a right to adopt or recommend what they believe to be the right and proper standard. In the society I may agree with you or I may not. It is my privilege to go before a committee and state my own views in the matter and if possible bring them around to my way of thinking. I do not suppose there are two of us here who would go before a committee and agree on the same line, and while I think it a most excellent idea that a report should be made every year by the committee, I think it is against the interests of the society that we should adopt the standard of to-day and let that stand forever.

Mr. Jellett:—It strikes me that the better way to handle this subject would be to receive the report of the committee and extend the committee so that the work would be continued. The wording of the constitution is for all classes of buildings and the report is only for certain classes of buildings. It does not cover the ground completely and I move that the report of the committee be received and the committee continued. (Seconded.)

The President:—You have heard the motion. The recommendation of the report is as follows:

1. That for all buildings, such as schools and asylums occupied almost entirely by children and youths under fifteen years of age, the minimum amount of air for ventilation shall be 1,800 cubic feet per hour per person.

2. That for all buildings occupied by persons over fifteen years of age the minimum amount of air for ventilation shall be 2,000 cubic feet per hour per person.

3. That for buildings lighted in part or wholly by gas the mini-

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mum amount of air supplied for each gas light shall be 3,000 cubic feet per hour.

That is counting two gas lights as equivalent to three persons.

Mr. Wolfe:—Regarding the difference between a child of 15 or thereabouts and a man, I do not see why there should be any difference. A child breathes much faster and consumes as much air and vitiates as much air as a man.

The President:—Is there any further discussion? The motion is I believe, for the acceptance of this report.

Mr. Wolfe:—I move that it be accepted and placed on file with the thanks of the society.

Mr. Jellett:—There is a motion before the house that the report be received and the committee continued. That has been seconded but does it cover the ground?

Mr. Wolfe:—I withdraw my motion.

The motion that the report be received and the committee continued was put and carried.

The President:—The report is accepted and the committee continued and the chair would announce what has already been endorsed—the appointment of the same committee for the further consideration of this subject.

The report of the committee on compulsory legislation, has, I think, been already made, and the chair would appoint as members of that committee for the coming year the following: William M. Mackay, James A. Harding, G. B. Cobb, B. H. Carpenter, and W. F. Wolfe.

As members of the committee on tests for the coming year the chair would appoint Mr. A. A. Cary, Mr. B. F. Stangland, and Mr. Henry Adams.

As members of the committee on uniform contract and specifications, which has already been under discussion, the chair would appoint Mr. S. A. Jellett, Mr. D. M. Quay, Mr. J. A. Harding, Mr. J. J. Blackmore, and Mr. A. E. Kenrick.

The Chair wishes to say one word, if the house will bear with him just a few minutes, regarding the work of the committee on tests as outlined by our president, Mr. Jellett. As I understand the duty of this committee on tests, it is to consist largely in their ascertaining information which in a large measure is to be the private property of the members of this society and is to be something which they can base their practice on to a great extent. This involves some considerations which in a practical way cannot have been thought of, and there are some things which, having had considerable experience in the line of testing, I have taken the liberty

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of calling your attention to. In the first place, the work of this committee, or of the people who do the testing for the committee, must be considered in two or three different ways. In making a test of any appliance, or of anything which is made, one can determine only certain things from the test. We can usually determine how valuable or how efficient the particular article is. But there is another very important thing commercially which often cannot be determined by any test and that is the durability, and I think it should always be borne in mind that the work of a committee on tests must not be accepted implicitly and one must not put too much importance on the report, as the report should be general and should be taken as simply that which shows efficiency. I would also say in regard to this work and the general work of the committee that so far as the laboratories at our institution can be used we should be very glad to co-operate with the committee in any particular way without expense, except such as comes in the way of mechanics and necessary preparations. This is a subject which I regard as one of a most delicate nature to be handled by a society, and I have made these statements simply because I feel very much concerned as to what may be its outcome in case the policy as mentioned here is fully carried out. If it is rightly managed and conducted discreetly it may be of very great help and assistance. But there are things in the way which, if not handled in the most careful manner, may make a good deal of trouble. I would like to hear an expression of opinion about this work, as I think it is of a great deal of importance. Mr. Jellett, won't you please give us an expression of how you think the committee on tests can accomplish their results?

Mr. Jellett:—That is a pretty difficult thing to do. My own judgment is that there is a good deal of information which members of our society lack now that they should have and that this committee on tests can supply them with. For example, we should have knowledge as to the efficiency of various models in radiation, as to the various forms of construction of radiating surfaces, as to the economical generation of steam in house heating boilers (makers' catalogues cannot be followed), the question of the supply of air from fans, loss from friction, and information of that kind that you cannot depend on manufacturers' catalogues for. For trade reasons they do not take in factors of safety. They give 100 per cent efficiency and in some cases I have heard of 160 per cent efficiency. One of the best known engineers in the country wrote me a short time ago to know how much percentage of reduction I used on figures given in a particular catalogue. He said he felt

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convinced that they were greatly exaggerated. He thought there was some fixed percentage that could be determined by which you could take so much and know you were pretty near right. Now the committee on tests can get such information without infringing anybody's rights whatever and communicate that information to the members of the society for use in their practice. That can be done without in any way interfering with anybody's rights that I see, and the sooner we get down to the basis of facts in making calculations the better it will be, not only for the engineers connected with this society, but for the men who make the apparatus. Blowers are frequently put in to do a given amount of work and they frequently fail, not because the blower is improperly built, but because it has been too small to do the work for which it is intended. This information our committee on tests can get for us. It will take time; but when any section of it is determined, it is determined on a basis that we can establish as being reasonably correct. We then can communicate this information to the various members through the medium of the bulletin that I suggested in my address. It is not wise to publish information of this kind, of course, in a trade journal. I gave in my address the reason for this—that it would have an injurious effect upon the advertising patronage of such a journal. But if we publish a small pamphlet of 10, 12, or 15 pages, whatever is needed, and send that through the mail addressed to our members, there is no endorsement of the results; it is simply for the information of members. It does not raise any questions whatever, but it does give information. Now I think that is what we are here for.

Mr. Cary:—My name was announced as being appointed a member of this committee, but when I hear all the requirements that are to be met it rather frightens me. I have had a good deal of testing work to do and I know what it means. It means a good deal of care, time, and attention, and as the members of this society have their reputation somewhat at stake it necessarily makes them all the more desirous of getting it down to something that they can back up. I do not know what has been done in the past by the committee on tests. I would like to ask for information whether this committee is to take tests that are being run in different parts of the country and collect them together, and if they believe that they are reasonably correct, to publish them and send them around in this form, as I understand, in a confidential bulletin. I think there should not be more than one distributed to each member of the society, and I think it might be well by number or some other method to keep them as a confidential circular. As far as this committee is con-

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cerned it would seem as though, if any of the members of the society were at all in doubt as to the efficiency of any new apparatus that had been put on the market, they might apply to the committee. If that is admissible, the work might run up pretty fast and it might take some little time to consider it properly and to give intelligent answers. I wish that the duties of this committee could be defined a little more plainly, so that the committee could realize a little bit the tests that they would have to undertake, so that the members would know just about what to call on the committee for, and, in short, just what position the committee should occupy towards the individual members of the society.

Mr. Wolfe:—I think Mr. Jellett has outlined exactly what we all want to know. But a man capable of making any such tests and reports would be cheap at $5,000 a year and it would keep him busy all the time. Have we as a society a right to ask these gentlemen to give their time to make reports to us which they pledge their honor as being true, for nothing? I do not think we have. It requires the purchase of quite an amount of apparatus, and we all know that if we put the same piece of apparatus in these two rooms we will get a somewhat different result in this room here, owing to the height of the ceiling, exposures, etc., than we will get in the other room. To make a comparative test of boilers you must subject them as nearly as possible to the same conditions. You must buy these boilers or borrow or steal them and connect them up to the same radiator. While Mr. Jellett has expressed exactly what we want, have we a right to ask them to do it?

The President:—In regard to this matter it is the opinion of the Chair that we will have to be reasonable in our demands on the committee. In other words, we can ask them only to give us such information as they may get. It would be utterly impossible, unless they were to give their whole time to this work of investigation and unless they were backed up by a very large amount of capital, to carry through investigations to any extent. I am backed up by an endowed laboratory and I spend lots of money every year, and if there was not a very large endowment which was made by some very wealthy men especially for this purpose, we could not do anything at all, because what little business comes in really does not pay one per cent of the actual expenses of the work; so we must not expect too much in this line of work, and that was the reason for my preliminary remarks. But it does seem to me that it is a very desirable thing to have this committee and to expect them to give such information as they can get and to put it in the form suggested. In regard to this fan investigation I might say that we are already

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at work in that investigation. I have four or five men at work on it and I presume it would cost—if it was paid for—a thousand dollars; the investigation we shall make, and we won't begin to touch one-tenth of the matters that are of importance in this one line. Such information, of course, would be entirely at the service of the committee, as I am quite certain that unless this committee were to give their whole time to it, they themselves could not go through the investigations. I think that the society will get a very great deal of good by retaining the committee, but we must expect to be reasonable in our demands upon them and allow them to present such matters as may come to them from time to time.

Mr. Cary:—In thinking over my coming year's work, I have quite a good deal of investigation to do in another direction. If I accepted the honor which you kindly offered me I would feel as though I should give a good deal more of my time than I can see my way clear to giving to this work. I would like very much to do everything I could to further the interests of the society. I surely have that at heart. But I think that if you will select some one else in my place you may get better service. I am afraid that my regular line of work will keep me busy much of the time, and it does not always stop at six o'clock. I am afraid I will not be able to give this work the attention it deserves. There may be some gentlemen who have more time at their disposal during the coming year than I have and I would suggest that some one else be honored.

The President:—You need not be alarmed, Mr. Cary. I think if Mr. Cary will accept the commission we will not work him too hard during the next year.

Mr. Cary:—When a man accepts a position of that kind he has a little self-responsibility which he cannot shake off. I feel as if I should do something if I accepted this position. I do not feel as if I had the time to devote to it by which I could acquit myself and feel that I had done a proper amount of service for the society.

The President:— I am grateful to the society for listening to the Chair on this point, as I feel that there were difficulties which could be better disposed of if talked over by the society in general. It seems to me that were we to limit the duties of the committee to reporting such information as they can get, it would be perhaps more satisfactory to them and it would be just as well to the society, and I would suggest that as a proper limitation of their work.

Mr. Jellett:—I think that is the intention simply that the committee on tests should report information as they get it and not make any recommendations; if they conduct a test and obtain certain results, simply notify us that they conducted such a test and give the results.

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The President:—The question is shall we impose on them any duty of making tests? That is what I have questioned—whether it would be right to impose that duty on any committee?

Mr. Jellett:—I do not think we should impose any absolute duty to conduct a series of tests. I think it is the duty of any member of the society who is making a test on any branch of its work, if he gets from that any reliable data, to send it to the committee on tests. I think that a part of my duty and I think every man here has the same feeling. I think that would result in time in getting a mass of useful information.

The President:—Then why wouldn't it be satisfactory to define their duties as simply a committee which shall be the custodian of all such information as it may receive?

Mr. Wolfe:—To facilitate matters I would move that the committee on tests be requested to submit confidentially to the members of this society from time to time such information as they have been able to collect that in their judgment is of interest to us. (Seconded.)

Mr. Barron:—I think now, as we have got this committee established, we have a very valuable acquisition. As I understand Mr. Wolfe's motion it is to make it a committee for the collection of data; that is, exact data that we can rely on, and the character of this committee will give it a certain standing.

Mr. Wolfe's motion was put and carried.

Mr. Wolfe:—Is this committee provided with funds for the publication and distribution of this information?

Mr. Jellett:—That is a matter which properly comes before the board of managers. They have entire control of the funds.

The President:—Is there any other business to come before the society?

Mr. Dean:—There is a little point which the president made in his address that I would like to hear discussed, and in order to bring it before the society I will put it in the form of a motion: That the council shall be instructed to offer a prize of $25 for the junior member of this society who shall in the ensuing year write the best essay on a subject to be provided by the council; the number of subjects and the manner of providing them, the selection of judges, etc., to be left entirely with the council, and that each succeeding year the council shall offer two prizes, one of $50 for the best essay and one of $25 for the second best essay, selection of topics, judges, etc., to be provided as specified above. (Seconded.)

Mr. Barron:—I would like to ask for information from the mover if there is any man here who could decide which essay is the best.

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Dr. Dean:—There are some very good things to be derived from it. This question I don't know that I could answer, because it would depend on who the judges are and it would depend on what the essays would be. But of course we must look to our junior members to make in time our best and most solid members, and the object of this is to interest the junior members, to get them to write papers and get them interested, so that they will take a better hold of the society than they oherwise would.

Mr. Cary:—I would ask for information as to how many junior members we have. I understand there are about nine.

Secretary Hart: Something like nine—only a few. We want more of them.

Mr. Cary:—Are we not starting in this a little early? The object is very commendable, surely. But I happen to be on the council the coming year and I see some difficulties ahead, as Mr. Wolfe has suggested, not that I am trying to avoid a little work or anything of that kind; but we do not want to have anything introduced here that is not going to result in complete harmony, and we have very few junior members—only nine. I question whether it is advisable at this time to go into this work. This of course is also coming out of the treasury. This does not amount to so very much—$25 or $75—but at the same time we have got to be careful with our funds for the first few years. If we can lay up a little money we would like to do it. Taking all these matters into consideration, the question is whether it is advisable to go into it this year, although in the end I would advocate such a thing.

Secretary Hart:—We have only a few junior members at the present time, but during the next year the council will at different times of the year vote on a great many members, juniors, and associates. Probably we will take a great many in. This resolution calls for the use of $25 this year. There were a great many in the heating and ventilating business before this society was organized traveling with the name of heating engineer on their card and they want to come in here for full membership. They are not entitled to it. If a prize were offered to the junior membership it would be an incentive to come in here as juniors, because if they were to be the fortunate ones and write papers which were accepted by the society it would give them a reputation. There is a great deal in Mr. Dean's remarks as to the junior members becoming our best members in the future. They probably will. Many young men are graduating from colleges, such as Cornell and others, who are taking up the matter of heating and ventilating more and more. I think in time they will be our most valuable members and I should like to see this passed very much.

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Mr. Wolfe:—If we are to adopt the resolution let us get all we can for our money. Instead of confining it to the junior members of this society, let us invite all who may be eligible to such membership. We may assume that we have a large part of the brains of ventilating engineers here, but there are some outside. The trade papers, as a matter of courtesy, I am sure, would all willingly say that a prize had been offered by this society for the best paper by a person eligible to junior membership at a certain time, stating what a junior member is. Our society will be discussed throughout the country and a great many people will know a lot about it. We will then interest a lot of people in this association and undoubtedly get a great many more junior members for our $25, and so it would be a good investment and we would get a lot of information besides. (Laughter.)

Mr. Mackay:—I am very anxious that we should raise the standard of the society to such a point that all the heating and ventilating engineers on the outside will want to get into it, but I do not believe we should put a premium for membership, for either juniors, associates, or members.

Mr. Wolfe:—I do not think the gentleman understands. A man before he becomes a member, must fill out an application, and if he is not competent to fill the requirements he does not get in. He may submit a paper and possibly it will be the best paper of the lot and he may get the prize, and yet he may not be able to fulfil the requirements and not get into the society, but he will think about this association, although he may never have thought of it before.

Mr. Barron:—I hope we will not do anything in this direction, because it is in the nature of Chinese civil service reform. It is offering a prize for the ability to write. Some of the ablest engineers that ever lived could not write an essay of twenty words and some to whom you could hardly apply the word able, and some like myself, who can write easily, can in practical engineering perhaps do very little. A man who has not literary ability, according to this, would stay in the background. It is a Chinese system, and we are not adopting Chinese systems until they whip the Japanese. Then we will think about it. (Laughter.)

Mr. Cary:—I cannot agree with Mr. Barron on this. One man may be better able to write a paper than another, but that need not stand in the way of his getting along. What we want is the information and we want it in the best form we can get it and I do not see why we should not encourage the man that can put that information forward in the best form. As I understand it, this is to go before the council and is not to be judged so much from the

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literary standpoint as from the engineering standpoint. It may be that some engineers are unfortunate in their methods of expression and cannot say what they want to say. But we want those who can express themselves well to come forward and put this information before the world and we will get the credit for bringing such information out. I think it is nothing we need be ashamed of and that it will be creditable to the society, although in saying this I do not need to go back from the position that I took in the first part of the discussion.

Mr. Jellett:—As I fathered this suggestion I suppose I ought to defend it. I have listened with a good deal of interest to what has been said. I still think that the suggestion is a good one. I have not changed my mind in the slightest. I do not agree with Mr. Barron. I have confidence enough in the council to believe that the mere literary form in which the article is put will not carry the prize. It carries me back to the time when I was going to a drawing school at night. The professor we had was one of the most sensible teachers I ever knew, and the question came up about a drawing that came in on a competitive test which was smudged on the edge. The Professor said, "I am looking at the drawing and not at the paper. If the drawing is correct I will pass it." I think that is the basis on which the council would act. I do not look at the question of offering a premium in the same light as probably some of the rest of you do. I do not take it that we want to offer any prizes for our regular membership. I think it is the duty of any member of this society to do all he can for the society. The junior member is in a different relation. We let him in so far and say, "You must stop; you have not yet had a certain amount of experience." Now, my own opinion is that taking the young men coming from colleges, from shops, etc., we want to interest them in the engineering side of the business and we want to interest them as quickly as we can. We look to them to do a great deal in the business of heating and ventilation. We all know, who give any thought to it at all, that science to-day is simply in the line of progress and development. We have a great deal to learn, and the more that we learn the more we find on the outer edge that we do not know. Now if any of these young men have time, and some of them have more time than some of the older members to win a prize (it can be a prize in any shape you please), it simply means that it is a notification that they have excelled in striving for the honor of winning the prize. It is not the mere $25—it is the honor of winning the prize in a competition of that kind. The council can outline what these subjects shall be, and I particularly excepted

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in making the suggestion, the matter of confining it to one subject that could only be written on by one or two or three men. I said the subjects chosen should be of such a general character that any of the junior members would be able to compete without reference to his special training; that with ordinary intelligence he would be able to get the facts and give the facts to this society. I believe that the suggestion was a good one, and I think if members here will consider it carefully they will agree with me, and it does not involve a lot of work on the part of our council. The invitation is sent out to those juniors and to any that will come in before September next, the papers to be ready for the coming January meeting. The council have to go over the other papers presented for the January meeting, and the reading of three or four or five more papers will not entail very much additional labor.

Mr. Wolfe:—I believe that the best papers that have ever been presented to the different societies of the world have been papers that have been thrown open to the whole world; that the authors of the papers were not necessarily members of any particular society. They were open to one and all who were competent. Now, we have a right to make the restriction that the author of a paper to be submitted shall be eligible to membership as a junior member of this society, and I believe, aside from any frivolous remarks about getting as much as we can for our money, etc., that it is better for the interests of this society to throw it open to all who are eligible to junior membership rather than to confine it to the few that we have, and I would amend the motion that it should not be confined to the present members but thrown open to all who are eligible to junior membership. (Seconded.)

The President:—The amendment is supported that the competition be thown open to all who are eligible to junior membership.

Mr. Cary:—If this is thrown open to the world, as you might say, we may have a great many papers coming in and they may run up into the hundreds. It is putting a deal of work on the council, a reasonable amount of which they would be very glad to assume. But if it is to be thrown open to the world, if there are to be 200 or 300 papers coming in, there is a great deal of work ahead, and I would like to hear the opinion of others as to what would be the best method of handling them. I do not know that we would have a rush of papers, but it will probably bring a good many in and in that case I think the council will have their hands full.

Secretary Hart:—I do not think this ought to be thrown open to the general public at all. I think that is all a great mistake. What we want is to offer a prize simply for the juniors in this so-

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ciety, and we will have a number of them in before that time. I think Mr. Wolfe has either misunderstood this or else what he offers now is certainly a great mistake. I hope the members will not vote for that proposition under any consideration.

Mr. Wolfe:—I know what I am talking about. Now we have nine junior members. That is the fact and facts are pretty good things to figure on. We know that we have nine. You may think that you may have 99 a year from now, but you have not got them yet. That is problematical entirely. Now, out of your nine it is very safe to say that there won't be over 33⅓ per cent that will submit a paper—that is three. For the sake of paying one man $25 to secure his interest, etc., you are certain to lose the good will of two men, and that doesn't pay. (Laughter), A man does not mind being beaten by two or three hundred in matters of this kind—that is all right—but it will make a feeling just as sure as can be, if it comes down to a decision between two or three. Regarding Mr. Cary's suggestions as to the work before the council, I do not believe that there is a gentleman here who ever had a man working for him at a dollar a day who could not give him a pointer on something; he knew something that the man who paid him did not know, and just so soon as we get so far advanced as engineers that our practical men who are making the connections and putting the work up cannot tell us anything, then we know too much. I appreciate the fact that it would be quite a little job to run over properly a hundred papers. I do not anticipate any such number; possibly it might be so, but I believe that they would get pay enough from it in the information that they would get—possibly not directly, but their attention might be called into a line that they had not thought of before, and summing it up, they would get enough information to make them glad that they had done it; 33⅓ per cent would be a pretty large percentage to figure; and then we are bound to make ill feeling, and that is something we do not want to do, if I understand the sentiment.

Mr. Barron:—As a substitute motion, I move you that the consideration of this matter be turned over to the council with power to act in any way they choose.

Mr. Wolfe:—I withdraw my motion and accept that.

Secretary Hart:—I second that.

The President:— The motion is to refer this to the council with power. The motion is now before you.

Mr. Dean:—I desire to read a part of the original motion. It says, "The number of subjects, manner of providing them, selection of judges, etc., shall be left entirely to the council. What I meant

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to convey by the "etc." was that the council had it in their power to ask some of the members of the society to assist them with these papers. They certainly have the power to select judges.

Mr. Barron:—I understood Mr. Dean's motion to be that way. But we now leave the expediency of the whole thing to the good judgment of the council.

The President:—That is what I understand the motion to be. Those in favor of the motion will signify by saying aye—opposed, no. (Motion carried.)

The President:—The original motion is referred to the council with power.

Mr. Wolfe:—I desire to make a motion which I think has been overlooked in the rush of business and might possibly be overlooked before we adjourn. I should like to move that a vote of thanks of this society be extended to Mr. Jellett for his able management as president of this society during the past year, for his careful attention to the duties of the office, for the time and thought that he has given, and for the information that he has collected and imparted to us, and that we express as fully as possible our sincere thanks and fullest appreciation of his labors in our behalf and the interests of this society.

The motion was seconded and unanimously carried by a rising vote.

The President:—The motion is unanimous, Mr. Secretary, and you will please convey the thanks of the society to our retiring president. Is there any new business to come before the meeting?

Mr. Barron:—I move you sir, that we proceed with the topics.

The President:—Our secretary has a notice.

The secretary read a letter inviting the members to inspect a household garbage destroying device in the sub-basement of the building.

The remaining topics were then considered.

The President:—Is there any further discussion on these topics? If not we will consider the subject closed. I believe that constitutes the last thing regularly on our programme. Is there any further business to come before this society?

Mr. Barron:—I would like to ask if there is any gentleman here who would like to further discuss Mr. Prather's paper on church heating.

Mr Connolly:—I would like to, Mr. President.

The President:—We will be very glad to hear from you.

Mr. Connolly then made a few remarks upon the previous discussion of this paper.

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The President:—Is there any further discussion on that topic? What is the pleasure of the society?

Mr. Cary:—As nobody seems to speak I make the motion to adjourn. (Motion carried.)

The President:—The meeting stands adjourned until the call of the board of managers and until our next annual meeting.

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XIII.

PRESIDENT'S ADDRESS.

BY STEWART A. JELLETT, PHILADELPHIA, PA.

(President of the Society, 1895 to 1896.)

Fellow members of the American Society Heating and Ventilating Engineers: It becomes my pleasant duty to welcome you to the second annual meeting of our society, which I do most heartily. The transactions thus inaugurated will, I trust, forward the objects for which we were organized, namely, "The promotion of the arts and sciences connected with heating and ventilation, and the encouragement of good fellowship among our members."

Those of you who attended the first meeting for organization, Sept. 10th, 1894, will recollect the interest taken in the preparation of our constitution and by-laws which were formulated at that time, and the unanimous opinion among those present that the time had come for and that there was a real need of such a society as ours.

The correctness of this judgment will be quite evident to any one who will examine to-day our list of members, among whom will be found heating and ventilating engineers of extended experience, professors of engineering in our leading technical colleges; others, successful designers and constructors of heating and ventilating apparatus.

It will not be necessary to review the work of our first annual meeting in January last. The published proceedings give you the complete details. Suffice it to say that the interest and enthusiasm of that meeting have lasted throughout the entire year, resulting in a more friendly feeling and better acquaintanceship among us, in addition to the information gained. That meeting also opened our eyes to the possibilities for usefulness that such a society as ours possesses.

The concensus of opinion among those I have talked with regarding our first meeting is that we acquitted ourselves well, as the published proceedings will show. Our membership has grown during the past year; we have at present something over 100, and we expect to largely increase this during the coming year. It is to

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be hoped that the proceedings of this meeting will be the magnet that will draw to us many desirable new members.

You will shortly learn from our secretary's report, and from the reports of the various committees, just what has been done since our last meeting. No doubt many suggestions will be made by them that will require your thoughtful attention.

Your officers and committees have given freely of their time during the past year, and feel very much encouraged at the results already reached, and look forward confidently to the future. It remains with you to say what the measure of our usefulness shall be. Our success will depend on the earnestness with which you, one and all, are prepared to sacrifice your time and ability to the general good.

The life and strength of any society like ours rests, first, on having fixed, honorable principles, and then on the enthusiasm and willingness of the members to work to advance those principles. The efforts of your officers, however well directed, will be of little use without the entire support and aid of the membership at large. It is not the work of officers and committees that will establish our reputation as a strong, earnest, useful association, but your work as members.

Give your attention to this fact especially and do not lose sight of it. Let each one, therefore, for the coming year, take to himself a share in the work and put his shoulder to the wheel. We have done well, but we should, and we can, do better. Fix your ideal high and keep it always in sight.

Having considered the duties we owe to our society as members, let us look to it that in increasing our membership we use the utmost care in selection. Do not vote to bring any one into our society whom you think is incompetent or unworthy to be a member; and, on the other hand, do your utmost to add to our number those that are properly entitled to come in under the clause of membership in our constitution. It has been brought to my attention several times during the past year that there is a feeling among hot air engineers, furnace men, etc., that they are not wanted in our society. I want to correct this impression at once and to state most emphatically that there is no ground whatever for such a feeling.

The wording of our constitution is clear, "a member shall be a heating and ventilating engineer." It does not confine it to any branch of heating and ventilating engineering, and we will gladly welcome all heating and ventilating engineers, whether they are advocates of either hot air, steam, water, hot blast, electrical, or any other system of heating, or any method of ventilation. The

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foundation of our society is a broad one, and we trust the superstructure will be worthy of it.

Let me urge that this society also give its support and assistance in every way possible to the various trade and technical schools, to whom we must largely look for the future engineers. Competition in business has to-day reached such a point that all manufacturers and many contractors are becoming specialists. This specializing largely prevents a young man from getting the thorough training and practice that his predecessors received, and he must, therefore, look to the trade schools for such training. It is important, therefore, and to the best interests of the public and ourselves, that we encourage the work of these schools. A higher standard of both workmen and work is one of the pressing necessities of to-day; the coming of the former insures the latter.

In this connection I would suggest, as an encouragement to our junior membership, that we offer two annual prizes, one of, say, $50, the second of $25, or any amount to be determined by the board of managers, for the first and second best essays on any subject or subjects connected with heating and ventilation that may be selected by the council. The papers to be judged by the council; the essays winning prizes, and any other thought worthy, to be published in our annual transactions.

The subjects chosen should be of such a general character that any of our junior members should be able to compete without reference to his special training.

There is still another side to the work of this society which should be constantly borne in mind, and that is the physical good that is being done for humanity by good warming and ventilating and its effect on the comfort and health of the people. Most, if not all, of our states have laws governing house drainage, safe construction of houses, and fire protection. Why not, therefore, reasonable warmth and good air, both of which our Creator provided the means of obtaining, and both of which were essentials long before any of the others came into existence, and the coming in of one of which (house drainage) has greatly increased the need of ventilation. It is just as essential in these days in this climate to warm and ventilate a dwelling as to properly build or drain it.

Let us as a society, therefore, urge on our various legislative and municipal bodies the importance of passing reasonable laws requiring both.

And now, as to our own particular wants; first, I would place the need of an assistant to our secretary, one who can give his entire time, or at least a large part of it, to the work of our society; whom

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we can employ for the first year at a salary, say, of $500 to $600; one who is interested in the work of heating and ventilation and has some engineering training.

The work of this society is increasing, and the necessary duties of the secretary are getting to be too much for any man engaged in other business to give his time to the work to the extent that we need it. As we are not in a position, financially, to engage the services of one equal in ability to our present secretary, the next best thing, it seems to me, is to have, in addition to our secretary, one that we might call an assistant to the secretary, or a corresponding secretary. While it may be necessary to get along another year without this help, I believe that having one will greatly assist the development of our society.

We should also look into the advisability of starting a quarterly, or, better still, a small monthly bulletin, giving our members short pithy articles on questions of heating and ventilation; a paper somewhat on the style of that published by the National Association of Builders. Such a paper can be made a medium through which our members may ask questions on matters about which they lack information and receive answers from other members who may be able to give the information desired.

Through this paper, information may reach our members from the committees on tests, standards, and others—facts they should be in possession of, as soon as determined, without waiting until our annual meeting. The information thus obtained through our committees may be of such a nature that it should reach our members through the medium of a society publication rather than through a public journal, as for example, information regarding heating surface and efficiency of particular forms of boilers, etc., the publication of which in a trade journal might seriously affect its advertising columns.

The editing of this bulletin might be done by the assistant secretary under the direction of the council.

I am a firm believer in the widest possible publicity regarding matters affecting our branch of engineering for two reasons: First, because, as the general public's knowledge of what is best in heating and ventilation is widened, in proportion will it require the assistance of the heating and ventilating engineers. And second, from a business point, I have always found my best competitor among the men who know how to do their work well, rather than among those who do not. Both reasons I believe to be sound.

In closing, let me add that it will become your duty to-morrow to elect the successors of your present officers. Carefully consider

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this matter. Select men who, in your judgment, will do most to forward the society's interests and advance its name honorably, leaving aside all personal friendships.

The work of the coming year will be no light task, if it is to be done as the society has a right to expect it done. Attend all the sessions of this meeting. Give careful attention to the papers to be read, and enter heartily into the discussion of the topics.

Let no man hesitate to speak on a subject if he has any information to impart, excusing himself on the ground that he is not accustomed to speaking. Remember that this is not a society of orators, but of every-day common-sense engineers and business men. We can all add something to the sum of human knowledge, and let it be something useful and worth remembering.

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XIV.

ELECTRIC HEATING.

BY W. S. HADAWAY, JR., NEW YORK.

(Member of the Society.)

The term "electric heating" is commonly used to express the frittering down of the high potential energy of electricity into the lower potential energy of heat. There is no well defined line of demarcation; the resultant is inseparable from the conveyance or utilization of electricity in any degree. The term is therefore a meaningless one from the heat engineer's standpoint, and it fails to accurately express the performance of useful work by the transmission of heat energy to a distance by means of electricity. The expression "electricity as a factor in a telethermal system" would be a better definition of the subject-matter of this paper, but for obvious reasons the shorter and simpler term is employed.

We are to regard heat energy as a commodity that can be generated or controlled in convenient form and distributed and sold, and in which electricity is used either directly as the high potential heat factor or indirectly as agent. The distribution and application of heat energy by electricity to arc and incandescent lighting, to metal welding and forging, and in the Cowles and Acheson furnaces are illustrations of results already attained in electric heating, and are properly discussed under the broad intepretation of our subject. The feature of the subject that we are to consider here is the practical adaptability of commercial electricity for heating purposes and for performing useful work under the conditions imposed in general industrial and domestic life, outside of the specific adaptations previously mentioned, and particularly in connection with other heat distributors for a multi-potential heat supply.

These applications may be roughly divided into two classes, according to the degree of concentration of the heat energy used, the first including low temperature heating, generally diffused and in large volume, and the second including high temperature heating generally localized and in small quantity. In heating on a small scale no adequate classification is possible; it is the shading

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of high potential heat energy into low potential heat work for many useful operations that primarily suggests the feasibility of heat transmission by electricity. The arbitrary line of temperature demarcation for heating on a large scale is here drawn at 250 degrees F. The closest common analogy to the differences between low potential large volume and high potential small volume heating is the distinction between volume and pitch in sound. As examples of the first class may be cited the heating of rooms and of water under atmospheric pressure; examples of the second class, are oven, sad-iron, and soldering iron heating.

The electrical horse power hour is the equivalent of 2544.6 British thermal units. For practical purposes the work in hand is to determine the useful work in different lines obtainable from this number of heat units at a fair average cost of supply; it involves, indirectly, determinations of relative efficiency between electric and common methods of heat generation, distribution, and application.

To show what the heating efficiency of different methods of application may mean, the following experiments, reviewed in the London Electrician for November 2nd, 1894, are cited: the determinations were the relative heating value of combustion and electricity by resistance. The same wires were heated first in a flame and then by electric current. It was found that with a platinum wire held in the flame less than 0.5 per cent of the thermal energy produced in the flame was transferred to the wire, while 90 per cent of the electrical energy used appeared as heat.

In another case an iron bar weighing about 20 pounds was heated by charcoal and then by electricity; in the former case about 0.75 per cent of the thermal energy was transferred to the bar and in the latter case 88 per cent. It is evident from the description that the calorimetric methods employed were rough, and the results are quoted more as qualitative than quantitative determinations. It should be observed that the foregoing illustrations are examples of our second class of heating. Figures obtained from tests made on energy required to heat one gallon of water by various methods of heat application show that there are wide differences in efficiency in our first class of heating. The heat capacity of the work performed was sufficiently large to express the relative differences in impartivity, and as we should expect, the lower the temperature of the work the larger the area heated and the greater the capacity the less the difference in ratio between heating by combustion and by electricity, and we can easily determine the conditions when the ratio is an inverse one.

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In room heating apparatus on continuous run we may figure that one watt, 3.4 thermal units, will heat one square foot of common radiator surface through 1.35 degrees F., and that 100 watts, or 340 thermal units, will heat the surface approximately 135 degrees F. above the room temperature. That is, for room heating, 100 watts are practically the equivalent of steam at low pressure condensed by one square foot of radiator surface with the difference between the room and the radiator temperatures as above stated. This, of course, takes no account of the heat capacity of the apparatus, which is practically eliminated by the condition imposed of continuous running.

We may safely assume that a fair average price of the horse power hour from large steam electric stations is five cents. It would therefore cost 0.67 cents to run one square foot of direct radiator surface for one hour, or the electrical horse power would keep about 7.5 square feet of radiator surface at the temperature differences noted for one hour. For direct comparison with a central station low potential heat distributor, we may compare this cost with figures of charges made by the New York Steam Co. as quoted by Unwin in his treatise on "The Development and Transmission of Power." The unit of heat used by the New York Steam Co. is stated to be the "kal," which is defined as the heat required to evaporate one pound of water from 100 degrees F. into steam at 316 degrees F. or at 70 pounds pressure per square inch. One kal is therefore about 1,110 thermal units. On a sliding scale the charge is stated to be 70 cents per 1000 kals to small consumers and 40 cents per 1000 to large users. As the price of five cents per horse power hour is to a large user we will compare it with the 40 cents per 1000 kal rate. For 40 cents the consumer secures 1,110,000 thermal units from the steam station compared with 20,518 thermal units from the electric station, a ratio of nearly 54 to 1, or practically 50 to 1, as a loss must be figured in the case of steam, dependent upon the temperature at which the condensed water is allowed to escape.

It is interesting to note in passing that while the relative generative efficiencies are about as eleven to one, the commercial rates are as fifty to one. Thwe ratio of the cost of heat energy from the electric station to the cost from the steam station is therefore practically four times as great as the ratio of the relative costs of production. This fact should be borne in mind in discussing Crompton's paper on Electric Energy, in which the influence and importance of the "load factor" is pointed out.

Clearly the steam electric light station ranks low as a heat dis-

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tributor for house warming on a large scale. Notwithstanding the great disparities in the cost of heat energy on a large scale, the uses to which small electric air heaters are put are surprisingly numerous. We are all more or less familiar with the use of gas stoves for room warming; it is found by experience that the electric air heater for auxiliary room warming, for bath and dressing rooms, for libraries, cabins in yachts and steamships, in mild climates, in early morning and evening, etc., serves its purpose economically and effectively. It is, then, on a comparatively small scale and in intermittent service that the electric air heater is useful when power is derived from the steam electric station and when the heat supplied is derived from electric resistance.

While considering the use of electricity in diffused heating on a large scale, we should not overlook the deductions made by Lord Kelvin "On the Economy of the Heating or Cooling of Buildings by means of Currents of Air" and published in the Glasgow Philosophical Proceedings, Vol. III, December, 1852, and followed by mathematical demonstrations in the Cambridge and Dublin Mathematical Journal for November, 1853. Quoting from these articles:

"In the mathematical investigation, it is shown that according to the general principles of the dynamical theory of heat, any substance may be heated 30 degrees above the atmospheric temperature by means of a properly contrived machine driven by an agent spending not more than about $\frac{1}{3\frac{1}{5}}$ of the energy of the heat thus communicated; and that a corresponding machine, or the same machine worked backwards, may be employed to produce cooling effects, requiring about the same expenditure of energy in working it to cool the same substance through a similar range of temperature. When a body is heated by such means about $\frac{3\frac{4}{5}}{3\frac{1}{5}}$ of heat is drawn from surrounding objects and $\frac{1}{3\frac{1}{5}}$ is created by the action of the agent; and when a body is cooled by the corresponding process the whole heat abstracted from it, together with a quantity created by the agent, equal to about $\frac{1}{3\frac{1}{5}}$ of this amount is given out to the surrounding objects."

We have thus introduced refrigeration as well as heating by electricity as agent. In editing his Mathematical and Physical Papers, Lord Kelvin added the following interesting note under the date of June 26th, 1881:

"The method of cooling air in unlimited quantities described in this article has been realized by Mr. Coleman, first in refrigerators used for the distillation of paraffine, and after that in the Bell-Coleman refrigerator for carrying supplies of fresh meat from North America to Europe, in a great refrigerator recently sent out for

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the abattoir at Brisbane, Queensland. The Bell-Coleman machine sends large quantities of air, cooled to 10 to 20 degrees C below the freezing point, into the chamber to be kept cool, and the general temperature of this chamber is thus maintained at the desired point.

"The method of heating air described in the article remains unrealized to this day. When Niagara is set to work for the benefit of North America, through electric conductors, it will, no doubt, be largely employed for the warming of houses over a considerable part of Canada and the United States. But it is probable that it will also have application, though less large in other cold countries, to multiply the heat of coal and other fuels, and to utilize wind and water power (with aid of electric accumulators) for warming houses."

In Anderson's treatise on the Conversion of Heat into Work, third edition, pp. 189 and 194, will be found descriptions of compressed air refrigerating machines made on the principle above described, and in Prof. Peabody's work on the Thermodynamics of the Steam Engine, pp. 464 and 465, will be found tests on a Bell-Coleman refrigerating machine. The use of electric motors in refrigeration has already received consideration of central station men, having been advocated by well known engineering authorities, but so far as I can learn nothing whatever has been accomplished in the use of motors for heating purposes.

When electricity is derived from water power we might expect a far wider availability of energy from heat of resistance for house warming than when electricity is derived from steam power. Careful deductions show that the cost of the horse power year must not exceed $6 in order to compete directly with good coal at $5 per ton for house warming in this latitude. The statistics of Prof. Swain show that the average cost of the mechanical horse power year from water power in this country is about $10; to this we must add electrical generation and transmission charges, making it seemingly impossible to realize a figure for electrical energy delivered that will not be three or four times the cost of heat directly from coal. In the Niagara power transmission scheme, I understand it is contemplated selling the electrical horse power year for $20. At this rate it may well be questioned whether there are not sufficient compensating advantages in regulation and control to warrant the very extensive use of the heat of resistance for house warming at least, and we are aided in this direction by requiring a lesser maximum capacity of the apparatus, as the heaters may be run night and day without additional cost within restricted areas.

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There are water power plants in the West where, with large falls, the cost of the horse power year is very low. In these places there will undoubtedly be many extensive applications of room heating on a successful basis.

In his paper on "The Cost of Steam Power," Trans. Am. Soc. of Electrical Engineers, March, 1893, Mr. C. E. Emery, cites the cost at Lawrence, where, with moderate fall, the cost of the horse power year from water power is figured at about $25, or practically the same as power generated from steam. We thus see that in the practical treatment of this question location conditions will control the breadth of applicability, including in these local conditions prime cost of electric power, cost of coal delivered, extremes of climate, average humidity, etc.

We have still another source of electrical energy to consider in connection with low temperature diffused heating in which power is derived from gas, oil, and air engines. Prof. Kennedy, in a lecture before the Royal Institution in April, 1893, on the "Utilization of Energy," places the theoretical efficiency of coal gas at 80 per cent. Of this a gas engine, he says, utilizes from 22 to 32 per cent. For diffused heating it is apparently more economical to distribute the gas than to attempt to convert it into kinetic energy and transmit it by electricity. In this connection I would call attention to Mr. Williams' paper before the Society of Arts, Boston, May 10, 1894, in which comparative costs of coal and various fuel gases are given, and in which it is shown that the gas equivalent of coal may, under most favorable circumstances, cost eight or ten times as much as coal.

The consideration of the relative values of gas and electricity for heating purposes is a matter which can only be inadequately discussed here, for the problem is a complicated one and demands the most thorough consideration. No one can underrate the facility of storage of gas, the economy of rapid and continuous generation, available heat from combustion, and discharge of by-products, whereas in electric lighting and electric heating every unit of light or heat secured represents an appreciable loss or depreciation of the energy converter. There are many advantages to be considered on the other side, such as localization, immersion of heater in working chamber, as in ovens, sad-irons, and water heaters, freedom from by-products, etc. In electric heating for domestic use, as in the use of gas for the same purpose, the bete noir of the situation is how to provide the hot water supply economically. It seems easier to arrange for this on a multi-potential heat supply system than on any system using gas,

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unless the heat wasted in gas manufacture can be stored and utilized.

In his treatise on Gas Engines, Donkin shows examples of gas engines of considerable size, furnishing power at rates less than can be secured from other prime movers. A case has come to my attention of a gasoline engine supplying energy at the dynamo terminals at a cost slightly under one cent per horse power hour. For high potential heat distribution from isolated plants this form of energy transmitter is generally available; but it may be seriously questioned whether, in isolated plants for domestic use, the hot water supply as commonly provided can be economically heated.

We may safely conclude from the foregoing illustrations that we cannot afford to use high potential kinetic energy for general diffused heating purposes on a large scale. The thermal unit is the equivalent of 778 foot pounds of work, and we would secure as much heat by applying a brake directly to the fly-wheel of the engine or prime mover as we obtain from the heat of electrical resistance which, so far as its results go, may be considered as friction. One pound of good coal has a potential heat energy as great as $5\frac{7}{10}$ horse power hours.

If we use as an average thermal value of the pound of coal 14,500 units, we can secure 9,400 units in a good boiler, or practically 65 per cent. There are many cases in practice in which this efficiency is exceeded, but Thurston's figures give 65 per cent as a fair average value. The fuel efficiency of the steam engine rarely exceeds ten per cent., and the heat incapable of conversion into high potential energy represents about nine-tenths of the whole, notwithstanding the fact that over six-tenths of the thermal energy of the coal is secured in useful work in the boiler.

It is therefore to this point we must look for our large volume heat supply, and we find in actual practice many illustrations which show that no great engineering difficulties are encountered in distributing the boiler energy, also that of the exhaust steam from the engine, for useful work at a distance.

The New York Steam Company's plants already referred to are distributing energy by live steam for heating and power purposes at about 80 pounds pressure, the pressure differing, however, in the uptown and down-town stations. The leakage and radiation losses are stated to be estimated at about 15 per cent, yet with this loss the heat-energy can be delivered on a very economical and successful basis.

The work of Birdsill Holly since 1877 in carrying out central

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station heat supply is too well known to require comment. It is important and interesting in connection with our problem, since it shows that central station diffused heat supply is entirely feasible. We are now able to formulate a multi-potential heat supply system in which the steam, either live or exhaust or both, is used for low temperature work, and electricity from generators in the same station is employed for all work requiring temperatures in excess of that of the steam; i. e., from about 250 degrees F. upwards.

In domestic work the steam heat would be employed for house heating and water heating for bathing and culinary purposes. Electric heat would be used for lamps, ovens, broilers, small portable stoves, sad-irons, curling irons, and all purposes requiring a high temperature localized heat. And a feature of such a combination not to be overlooked is the facility with which ventilation and heat regulation can be secured, since all the elements are at command to force an abundant supply of heated pure air through the building to be warmed.

There are no new or untried features in such a combination; practically all the elements necessary for the work are already employed, though in a somewhat disjointed form as far as complete flexibility of heat supply from one center of distribution is concerned. In the "Electrical Engineer" for April 5, 1893, will be found a description of the Springfield (Ill.) electric light and steam distribution plant. In operating this plant the exhaust steam is used for warming buildings, but so far as I am aware no systematic attempt has been made to carry out a multi-potential heat supply. The revenue from building heating, I am informed, was over $12,000 during 1894, which is largely clear gain, considering it from the standpoint of the common electric light station, barring of course the fixed charges for the extra equipment. An instance occurred in Boston of a small, centrally located electric light station paying its expenses by the sale of steam for heating purposes.

As bearing upon this subject I beg to quote from a recent letter from the American District Steam Co., of Lockport, N. Y.:

"We observe that you recognize the futility of electricity competing with steam for diffused heating on a large scale, but there is a wide field for electrical companies in connection with their exhaust. In blocks of buildings where power is required to run elevators, or for other purposes, the proprietors will run their own power if they have to do their own heating, but if the electric company can heat the building it can get the power at a good profit, and there is a profit in both heating and power."

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"We have just constructed a heating plant for the Rochester (N. Y.) Gas and Electric Co., who are doing just this thing; they start off with 5,000,000 cubic feet of space to heat in manufacturing and business blocks, and secure the running of several engines in the same buildings. They supply the steam from their station in underground pipe and power by wire. They could not get the power without doing the heating."

Careful study of the question of multi-potential heat supply from both the engineering and business standpoints, can hardly fail to give the utmost confidence that results of the greatest value can be obtained along this line. A total fuel efficiency of 35 per cent. for combined low and high temperature heating is certainly obtainable, and probably a still higher efficiency may be secured from operations on a large scale. It is in this connection that I look for the best immediate results of electric heating in domestic life. The electrical engineer of to-day realizes that the ordinary light and power station is extremely wasteful as a heat generator and distributor, and the only way to improve these conditions is to introduce a basis of supply in which the load factor is a larger percentage of the station capacity and in which what are now wasteful by-products may be utilized. This feature should receive the greatest possible care; space does not permit a discussion of Crompton's valuable paper on this subject and its practical bearings on the conditions existing to-day in this country, as shown by the reports of the Massachusetts Board of Gas and Electric Light Commissioners and the data collected by the National Electric Light Association.

Aside from electricity for cooking we find in the modern apartment houses a comparatively high distributive heat efficiency. The rooms are heated by steam, as is the water for bathing and cooking purposes. Electric lighting is available, but low heat efficiency is found in cooking, except in cases where gas is available. I do not question the value of gas for fuel in cooking; I take the ground that when a boiler plant is required for room and water heating and the electric plant for lighting, the use of gas in cooking is unnecessary and comparatively expensive. In these houses electricity is already being used instead of alcohol lamps for heating chafing dishes and small tea kettles for five o'clock tea, also for heating, curling irons, sad-irons for laundry work and pressing, etc., and it appears to be a question of but a short time before electric ovens, broilers, and small portable stoves will replace the range or the gas stove on a considerable scale. The apartment house supplied with its own boiler and electric lighting plant ap-

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proaches more closely the proper conditions for electric heating than any other mode of domestic life, as all the conditions essential to economical working are already present.

The foregoing deductions have been introduced to indicate broadly wherein the true economical basis of electric heating lies. Like all general considerations they are qualitative rather than quantitative in character. We find in industrial and commercial practice a great number of heat applications, either at high or moderate temperatures, in which close regulation and facility of control are necessary and where electric heating on some scale is applicable. The introduction of electric lights and motors has brought into use in central stations and isolated plants a vast amount of electrical generating apparatus, so that at the outset our problem is almost wholly one of applying electric heating apparatus on circuits already established, primarily for other purposes. On these circuits we are usually able to show apparatus to do the work required better than it is at present accomplished. First cost and cost of operating are not the sole considerations in any apparatus; in addition to the cost the collateral advantages derived from its use must be considered.

In domestic work there are large numbers of chafing dishes, small tea kettles, sad-irons, etc., in use. Once used the value of this method of heating is well appreciated, and extensions of it are made to more and different work. In this slow, conservative way, electric heating in households is progressing, and there are indications of a more and more rapid general reception and use.

There are some installations in which all or nearly all the cooking is done by electricity. These are generally successful and economical, according to the extent to which extensive water heating is eliminated. Laundry and pressing irons are found almost uniformly satisfactory. So with all devices used in the dining room, as for example chafing dishes and small tea kettles. When it comes to the kitchen the same feeling of cleanliness and elegance as for the dining room is expressed and hoped for, but the housewife is not so intimately in contact with the apparatus, and we encounter ignorant manipulation which, however, generally does no other harm than to add to the expense of running. But fortunately the manipulation and control of the apparatus is so simple and saves the servant so much hard work that an honest effort is usually evident to use it economically.

In industrial work the progress of electric heating is more rapid than in domestic applications. There are cases where heating by electricity is found cheaper than by fuels, setting aside all collateral

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advantages. In electric cars the equable distribution of heat on a basis of effective warming is sufficient, in the judgment of shrewd business men, to warrant employing the method and apparatus, even at considerably greater cost than former methods of heating.

We have before us for the future two methods for the distribution of heat; the first a multi-potential heat system in which steam and electricity are the means of transmission, and second, a constant potential heat system in which electricity is employed as agent for diffused heat work in large volume, and the heat of resistance, either directly or with the additional heat of combustion of carbon, is used for high temperature purposes. The first is a combination of well known engineering practices and represents elements in successful use at the present time. The second method appears more difficult, as it includes new methods of application and untried apparatus. For the present we have to approximate the probable final conditions by using materials at hand, so far as they will go, with reasonable economy, using every energy to broaden the general conception of the help and convenience arising from central station heat supply.

PRACTICAL APPLICATIONS OF ELECTRIC HEATING.

I. Car Heating.—The electric car heater has a small coal stove as its chief competitor. The car stove is usually placed midway in the car, the seat on one side having been cut away to let it fit in snugly, taking thereby the seats of two passengers. This system of heating is manifestly a poor one considered on the basis of heat distribution, and it also aggravates the faulty ventilation of a street car by gases from the coal burned.

In house or space heating on a considerable scale the generator can be located at a convenient point and the heat energy distributed efficiently by hot water or steam. In electric street cars the space to be heated is so small as to practically preclude the economical use of this method of heating. Hot water storage systems have been suggested and tried; but the objections of charging, attendance, etc., are evident.

The electric railway company usually owns its own generating plant, which has been erected specially for the purpose with good boilers, efficient engines, and large unit generators. The cost of power is a minimum, and there are cases in which it is figured to cost not over $2 per horse power per month. It is in a measure the ability to generate the power cheaply that makes it profitable to operate street railways by electricity. This same reason makes a certain amount of energy available for effective car warming at

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reasonable cost. The amount of energy available is dependent upon local conditions peculiar to each road.

Most of the car heaters now used are air heaters; that is, the resistance is so arranged as to permit the air to impinge directly against it and carry away the heat by convection currents. The heat ascends to the monitor and is rapidly diffused with the cold air sifting in through openings in ventilators and window frames.

It may well be questioned in the light of modern heating practice whether this form of heater is best adapted for the peculiar conditions in car heating work, which really should be not heating at all, but effective warming. In common house heating, where electric heaters are used to give results immediately, they are connected in circuit; this is a better way to make the heater than a radiating surface. But in car work, where the heater is practically continuously in circuit, the radiator forms a better means of keeping a large percentage of the heat delivered at or near the floor of the car and about the bodies of the passengers.

The car heating tests made show that with the use of about four horse power the interior of the car can be kept practically at 50 degrees F. From one point of view this is too low a temperature for comfortable passage. And yet if the heater is devised to deliver a part of its energy to the floor of the car, to keep it warm and dry, and about the limbs of the passengers, this is high enough for practical purposes. The problem of car heating practically resolves itself into providing a form of foot warmer heated by electricity and used for effective warming rather than for heating per se.

On the Esquimaux plan of huddling together for warmth, a car can be kept at about 40 degrees F. by animal heat; each adult passenger gives off 190 heat units per hour, or 14 passengers will give off as much heat as one electrical horse power hour. There are cases in practice in which the animal heat on some runs is practically the equivalent of the electrical energy used in heating. Clearly, then, the proper use of electrical energy is on the basis of individual effectiveness rather than for heating as commonly understood.

Using the methods commonly employed for computing the heat necessary for warming, a 20 foot car requires eight horse power hours to keep it at 65 degrees with the outside air at zero. In the cars examined in use the energy supplied for heating by electricity was about equal to the loss from glass radiation. There are cases in which the energy used for heating by electricity is 40 per cent of the energy used in operating a particular car. And

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yet, assuming that five horse power is a fair average for use, the cost is about $10 per month per car for heating, or about 33 cents per day or two cents per hour. The use of five horse power is a high one for effective warming, as it would heat 37 square feet of radiating surface to 185 degrees with the car at 50 degrees, while with the best systems of radiation for complete diffusion yet suggested the surface available is about 30 square feet, requiring four horse power to heat.

While most of the electric car heaters now supplied do not meet the conditions here imposed the fact that several thousand cars are equipped with and are using the heaters attests their value. I beg to quote in this connection from a letter written me by a well known street railway expert:

"I think that the decision for or against heating in any particular case will have to be given with the distinct understanding that collateral advantages and not coal economy form the real criterion. You will remember that I spoke to yiu about a large plant which had been using heaters this winter with a very great expenditure of power. I had a talk with the manager a few days ago with the following results. He admitted immediately that it is costing him considerbly more, in fact, about four times as much, to heat his crs by electric heaters as it did by coal stoves. He says, however, that he saves two seats in the car, that the people like the system of heating, and the cars are more attractive for this reason, and that on the whole he believes in it and would not go back to the old system, nor would he fail to adopt electric heating if the decision were to be made again."

This expression of opinion has been selected, notwithstanding the unfavorable comparative cost statement, to illustrate how far we have to be governed by cillateral advantages in deciding for or against any particular application of electricity for heating purposes.

More large contracts for electric car heaters have been closed the past season than ever before, and there is every evidence that the electric car heater has become a staple commercial device. It would seem in view of the facts, that the statements contained in Vol. I of the transactions of this society regarding electric car heaters should not stand without correction. The Metropolitan West Side Elevated Railroad of Chicago are now heating by electricity 155 cars, each 38 feet 8½ inches long; 7 feet 10 inches wide; center height, 8 feet 6⅞ inches; side height, 6 feet 7¾ inches. Glass surface is 208 square feet. There are 12 heaters to each car, using maximum of 7,000 watts. The energy used is divided

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into two parts of 2,600 watts each and one part of 1,800 watts. The practicability of the equipment is shown by a recent order for 25 more equipments.

II. Air Heaters.—Outside of car heating these heaters have been used to a wide extent. One of the largest installations is in the office building of the Cataract Construction Co., at Niagara Falls, where all the heat is derived from this source. In cabins of steamships and yachts, bath-rooms of houses, offices, libraries, etc., they are found useful devices. The writer pointed out in "Heating and Ventilation" for December, 1895, the relation which these heaters bear to steam heating systems.

In England and France installations have been made on a considerable scale, and the work is of course simpler than the problem confronting us in this latitule, where the maximum capacity requires to be nearly twice the average. In heating the Vaudeville Theater in London, the engineers write that they had to compete against a low pressure hot water system. There was difficulty in finding a suitable place for the furnace on that system, and in using electricity this difficulty was overcome. It is found in ordinary cold weather that only two or three hours' heating are required, but with hot water systems it is impossible to limit the time in this manner, as the water takes two or three hours to heat up and the same time to cool down. The charge for current is 4d. per unit (about 6 cents per horse power hour). The lessees of the theater have expressed themselves perfectly satisfied with the results.

In this work the fact that heat is used only intermittently produces economical results, with even very high current rates. Take the case of a bath-room: capacity of heater, one horse power; duration of use per day, 20 minutes; rate for power, 10 cents per horse power hour; cost per day $3\frac{1}{3}$ cents, or practically $1 per month.

III. Electric Cooking.—The results obtained in this line have been in a number of detached installations. Enough has been accomplished to show that electric cooking apparatus is practicable to use, economical in running cost, and extremely simple to operate.

Theoretically, of course, the oven is the device of highest efficiency and it is also found in practice a device of the greatest practical value. In Science for September 15, 1893, will be found the most comprehensive data regarding the comparative cost of operating the electric oven and the common cool range yet published. It is shown that the cost at average rates for electricity is

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practically the same for the coal range and electricity, provided an auxiliary water heater is used with the electric oven. It is not always possible in practice to confine the electrically heated apparatus to types as economical as the oven; but in a plant operated for several months and in which ordinary types of cooking utensils were used, the cost was found to be 2.5 cents per person per meal. Separating the energy used in this latter case for cooking from that employed for water heating and the cost would be reduced by about one-third, or to 1.7 cents per person. Even at the 2.5 cent rate the cost (including time and attendance) compares favorably with other sources of heat for cooking.

IV. Industrial Applications.—In factory work all the elements for a multipotential heat supply are usually present and the field for electrically heated devices extensive. Three examples have been selected as illustrating this class of work.

A. Equipment of a brush factory.—In this instance pitch is used to fasten bristles in the brushes and is kept above 300 degrees F. in jacketed electrically heated pans. In addition, hot plates and glue pots are used, all heated by electricity. Current is derived from a dynamo driven by a gasoline engine. For a run of ten hours the cost of heating each pitch pan is about 4.5 cents, which is considerably less than was the cost of running by gas.

Commenting on his plant the owner writes:—

"When we built our factory we had confronting us the problem of obtaining high temperatures for heating pitch and other applications without employing gas or other forms of flames or fire in the shop which were objectionable from the underwriters' standpoint and which we have solved by the adoption of electricity for these purposes."

B. Sad-irons in a linen factory.—This installation consists of 125 9-pound irons heated to about 750 degrees surface temperature. For this plant additional dynamos were bought, and its success is evidenced by the fact that it is shortly intended to double the equipment. Each iron uses 550 watts or about $\frac{3}{4}$ horse power per hour as a maximum.

C. Glue pots in book binderies.—Two installations of 25 pots each. These show the value of electric heating in the subdivision of heat energy. The pots are provided with water bath, and the energy supply so adjusted to compensate for heat loss without material evaporation. The energy used by each pot is from 150 to 200 watts.

These may be regarded as typical illustrations and indicate roughly the adaptability of electric heating in industrial work.

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Where electricity is used in place of flame or fire the ventilating problem becomes much simpler, and this is of great importance in crowded work-rooms.

It is not too much to claim that electric heating will materially influence the work of heating and ventilating engineers. Now that electric lighting installations are handled by heating and ventilating engineers it is a short step to render the entire heating system homogeneous, looking to one source—the boiler—for all the energy needed for heating, lighting, and ventilating. It is possible to economically regulate and provide storage capacity for both the high and low temperature factors; the plant becomes compact, self-contained, and simple and economical in units of moderate size. The system is elastic to the highest degree.

DISCUSSION.

Mr. John Gormly:—I would like to ask Mr. Hadaway if he has any data in reference to the weight that is required to be carried in a car radiator. That is, for the heating of a car so much dead weight has to be carried; has he any data to give us on that subject?

Mr. Hadaway:—In the experiments made the weight of the radiating surface has varied from 125 pounds as a minimum to 210 pounds as a maximum.

Mr. Stewart A. Jellett, (Vice-President Mackay in the chair):—Gentlemen, I am not posted on electric heating, but there are one or two things brought out in this paper that interest me very much, and I would like to say a few words about them in order to get further information. What has impressed me all through has been that there is no particular difficulty in electric heating, that is, with the generation and transmission of the electric heat, but that the one thing which stands in the way of its introduction is the cost. It is a comparative question throughout. Therefore I would like to ask for information as to what is now under consideration by electrical engineers throughout the country towards the reduction of cost of generation of electric current, and second, with respect to the transmission of the current. I was talking to a gentleman a short time ago who was very much interested in this matter, and he told me that he was at work with some others on a new problem of generating gas from fuel and passing it directly from the furnace to the engine without the use of a boiler, and in that way he hoped to very largely reduce the cost of generation of the electric current; that the experiments so far conducted had been of such a nature as to lead them to hope for ultimate success; that ten of

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them had gone together and contributed some $5,000 for further experiments in this direction, the idea being to take the cheaper forms of fuel, build a specially constructed form of furnace, and utilize the gas from the fuel directly in the engine—simply an expansion engine—and to have this engine directly connected with generators. He said he was not in a position to talk definitely as to the cost of this, but that experiments made so far had shown them that there was a probability that it was possible and, if possible, that it was certain to be less expensive. I understand that the Baldwin Locomotive Works are considering, in connection with the new electric locomotives, a cheaper method of electrical generation. Now, if this can be accomplished, it seems to me that it largely meets the objection to electric heating; that is, the cost. I have faith enough in the electrical engineers of to-day to believe that if the cost can be reduced in the original generation of the energy the cost of transmission can be largely reduced, as it has been during this last five years. There certainly has been a material reduction in the cost of transmission. With these two features fairly met, those of us who are heating engineers in other lines will be confronted by a competitor in the shape of electric heating, and it is to our interest to know as much about electric heating as we can and to aid in every possible way its furtherance. I take it that if successful it is an ideal system. It largely minimizes the question of labor in the household, and labor is one of the bugbears of housekeeping, as most of us know who have tried it. It gets rid of all the annoyance or dust and dirt accumulation in the basement of the house, and it also gets rid of the annoyance and danger from vitiated air and coal gas. The system is simplicity itself and the most convenient I know of, and many of us would be willing to increase the cost of heating our houses to save the trouble and expense that we now have. I hope to hear further discussion on this subject from other members.

Mr. Hadaway:—I would like to answer as much of that argument as pertains to the reduction of the cost of electricity for the successful development of electric heating. While I have no doubt and have every confidence that the time is not far distant when material advances will be made in the generation of electricity, yet from the standpoint of decreasing the cost of electric heating, no further advancement of our knowledge of the generation of electricity is required. I might cite a practical illustration as showing what I mean by that statement. In one of the largest dry goods retail houses in Brooklyn they have until recently been using a great many sources of heat in their work. They have used

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gas for high temperature work. They have used electric lighting. They have used all the exhaust steam they had and they have supplemented that by live steam. We have taken that plant, removed all the gas heating apparatus from it, substituted electric heating apparatus for the gas apparatus, and the manager has told me very recently that he is saving in his operating expenses all of his former gas bills. That is the point that I want to bring out distinctly in the line of electric heating—that all that electric heating means from a thermo-dynamic standpoint is simply this; that you put your fuel into an economical generator, that is, something that transforms the potential energy of fuel into an available form. Take the case of a boiler; we get from 65 to 70 per cent, in some cases even higher than 75 per cent. There we have, at a temperature of, say, 300 degrees, the common pressure of steam, about 65 per cent of the actual fuel energy. The question is what are the demands for the use of energy in commercial and domestic life that will require us to transmit and transform that boiler energy so as to successfully meet the conditions? Taking the line of argument which I worked out in the Engineering Magazine last May on the telethermal system, I found a very large number of tests showing that the relation in actual life between the low temperature energy and the high temperature energy is practically as five is to one; that is, of the six parts of energy used there are five parts of energy at a level below 250 degrees and one part above it. If we take away the energy which we have got locked up in a boiler, say 65 per cent of the coal energy, put that energy through a steam engine, we will get a ratio of transformation of the boiler energy that practically meets with all the requirements such as we find in average domestic and commercial life. I have figured it out in several cases—this case which I have cited is merely one—in connection with apartment houses, shirt factories, and establishments of that sort where those conditions are met very successfully. So that the point I want to make in connection with electric heating at the present time is this, that while car heating, etc., are successful by electricity, they are really special cases in the development of electric heating; that the real development of electric heating comes from that point where you start with one source of energy and distribute it at different temperatures by means of electricity for the high temperature work and steam for the low temperature work in combination.

Mr. Harvey:—I would like to ask the gentleman, for my own information, if he ever tried to find out the difference in using electric direct radiation, or by heating water with electricity and letting the heat be distributed through an ordinary hot water apparatus—whether he has ever tried or even seen it tried.

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Mr. Hadaway:—We have, as a matter of fact, tested a large number of hot water systems, particularly one in which it was intended to locate the electric heater in the center of the car and distribute the heat through the car by means of water which was heated by the heater. Of course, that is one way of distributing heat by electricity, but it is a much more simple and direct way to proportion your resistances so that they spread out through the car, instead of using water or liquid to accomplish that purpose. You find, as a matter of fact, that it is quite as simple as to construct the apparatus with the resistance spread out as to construct an apparatus witht the generator localized and then distribute the heat energy by hot water.

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XV.

HEATING AND VENTILATING OF LARGE CHURCHES.

BY H. B. PRATHER, BUFFALO, N. Y.

(Member of the Society.)

In the sanitary and effective heating and ventilating of our large modern church edifices the engineer finds a wide field for effort, and probably no other class of buildings calls for more careful study or comprehensive knowledge and application of the scientific and practical principles of heating and ventilating. Certainly present success in this line has had many years of growth to spring from and the results of very numerous whole or partial failures and experiments to profit by. In this field, the same as in others, many of the failures are due to the wholly inadequate sums appropriated for the plants and to reckless competition on the "go as you please, every competitor to present his own plans and specifications" basis.

It has taken the public a long while to learn that something, or a great deal, cannot be secured for nothing or a very little, no matter how glittering the preparations and representations of the "lowest bidder." Highly colored lithographs and elaborate delineations of imaginary heat and air currents may secure contracts at ridiculously low prices, but they will not heat and ventilate buildings economically and effectively. The contractors are not a whit more to blame for these things than the purchasers. This point is especially pertinent in church heating and ventilating. Men who, in their ordinary business transactions, expect to pay in proportion to and for what they get, when they are appointed on a church committee immediately become possessed of most exaggerated ideas of economy, of the immense privileges accorded to contractors in allowing them to bid on church work, and of the value of plants in such buildings as an advertising investment to the contractor, and expect, as a rule, to get what amounts to "something for nothing," a first-class plant for the price of a shoddy imitation; then, having made some such a deal, they "crow" about their achievements in the interests of the church, and after

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the plant is installed they are the first to condemn and complain; and the unfortunate contractor usually has to furnish considerable more than he ever contracted for and please every officious and cranky member of the congregation before he can get even a partial settlement. It follows that for his own safety, as well as for the best interests and the advancement of the business, the heating and ventilating engineer should exercise especial care and liberality in the design of church plants, taking advantage of the lessons of other plants, and see that either first class plants are advised and contracted for or none at all. The distinction is made between large and small churches, as the financial limitations and usual demands and expectations of purchasing committees differ radically for the two classes.

The heating and ventilating of our modern church buildings is rendered still more complex by the numerous different styles of architecture, each requiring somewhat different treatment. Furthermore, the acoustic effects of the methods of induction and eduction of the air, the direction of the resultant air currents, and the stratification of the air must be considered. As the first step in the design of a plant the demands and financial limitations of the church people must be considered; it must be ascertained what kind of a plant is feasible with their conditions, whether a single natural draft warm air system with indirect and direct radiation, or furnace heat and some ventilation only, or a simple fan system with massed heating coils and mechanical ventilation, or a more complete system with an induction fan and possibly also an eduction fan with hot and tempered air conduit systems and a delivery of mixed air of proper temperature into the building and hand regulation of the air mixing or this complete system with thermostats and automatic regulation of the air mixing, i. e., automatic regulation of the heating and ventilating.

We will consider in this paper principally a complete plant of the last named form, its details and various features as applied to different styles of architecture, its relative first cost and cost of operation, and the relative cost of various simpler forms of plants with certain features of the complete plant eliminated, and thus present our subject as comprehensively as possible. The plant and features we will consider have been "tried in the fire," and the proportions formulated are based entirely upon successfully operating examples with the lessons of their experience utilized, their valuable features emphasized and faults eliminated. No attempt will be made to go into mathematical and chemical

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analyses and details, however interesting such might be. No pretense is made that the "acme" of all engineering in this line is presented, nor that some more talented brother may not have many criticisms to make and changes to suggest. Furthermore, a reasonable cost, both of installation and operation, will be kept in view at all times, the data being based on competitive prices as actually exhibited every day.

The primary wants and limitations of the possible plant having been clearly ascertained, then the next step in the design of the heating and ventilating plant is the "getting together" of the architect and the heating and ventilating engineer. The architect is practically the autocrat of the situation and can generally make the lot of an engineer an easy one or a hard one, as he wills. The practice of first designing the building and afterwards the heating and ventilating plant is radically wrong, although it is the usual custom nine times out of ten, and in no class of buildings has this been so much in evidence as in church structures, and the results have been especially bad in the matter of provision, or rather lack of and improper provision, for the education of the vitiated air. The walls being principally outside walls, it is often quite a problem to get both the induction and eduction flues in inside walls or places, or "pilastered in" on outside walls, but that they shall be so situated should be an "iron-clad" rule, with the exception, of course, of eduction flues when an eduction or exhaust fan is used. In any plenum system (without exhaust fan) eduction flues in outside walls will invariably have obnoxious down drafts in low barometer and excessively cold winter weather, and when windows and doors are opened, that are highly objectionable.

By due consideration of this vitally important matter of induction and eduction flue areas and positions at an early period in the designing of the building, proper arrangements can nearly always be secured. Warm and fresh air should be introduced and the eduction outlets arranged in the auditorium in such manner as to cause a flow of air away from the vomitorium or source of sound; i. e., the pulpit, with the principal egress at the sides and opposite end of room from the pulpit. The vestibules should be liberally provided for, large marble-capped pedestal registers being preferable in these parts; these pedestals serve an additional useful purpose as "foot warmers." It is essential that with the opening of the doors between vestibules and adjoining rooms warm drafts and not cold ones will flow in from the vestibules.

These general principles regarding air inlets and outlets are further affected by the roof structure. Nearly all churches can be

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divided into two classes; first, those with closed roofs, and second, those with domes and lanterns with more or less glass surface in them. The Gothic is the principal representative of the first style and the Romanesque of the latter. All glass surface in domes, lanterns and skylights should be double, but it rarely is so. In auditoriums with closed roofs the fresh air inlets should be large and the major portion located at the pulpit end of room,with one or two inlets at the sides and also some at the entrance end. In auditoriums with dome or lantern roofs the larger portion of the fresh air, at least two-thirds, should be introduced through small grills or registers in the ends of the seats, these seat inlets being small, usually about six or eight by ten inches, and well distributed. There should be also a few large supplies at the pulpit end of the room, whose especial function is to fill the dome or lantern with warm air. Without these numerous seat inlets the volume of warm air in the dome or lantern, after partly cooling, falls, and those people sitting in the part of room directly under the dome or lantern feel cold down drafts, or what are sometimes called "convection currents."

The constant ascent of fresh warm air from the seat inlets counteracts and dissipates the down drafts and obviates the evil. Floor registers should never be used, and the discharge of hot air directly against people should always be avoided. The air currents should never discharge directly against glass surfaces of windows, but should flow parallel with the window wall. In rooms having galleries provisions should be made for the flow of part of the accumulated warm air and heat under the galleries through grills or screens placed near walls up to the galleries. There should also be provided vents at the rear of the galleries. The gallery vents are not necessary for galleries around main Sunday-school rooms which have small class rooms opening directly off the gallery and floor below. Coils of direct heating pipes should be provided under large windows in galleries, these coils having from 200 to 500 feet of 1-inch pipe and rarely more, according to the size of the window and depth of the gallery.

All small class rooms, pastor's study, library and committee rooms should each have its warm inlet and vent outlet, and preferably, in addition to the general heating and ventilating system, the pastor's study, toilet rooms, the library, reading and committee rooms should have an independent direct steam or hot water plant for the heating during week days, when the remainder of the building is not in use. In determining the air supply for the various parts the following proportions have given most excellent results, viz.: an air delivery into the auditorium of a volume equal to the cubical

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contents every twelve to fifteen minutes in very large rooms with high domes or lanterns and a contents of 150,000 to 250,000 cubic feet, and every ten minutes in smaller rooms under 150,000 cubic feet and with closed roofs; inlet velocities of from 250 to 350 feet per minute for seat inlets and pedestals, and from 500 to 800 feet per minute for wall registers or inlets located eight feet or more above the floor; vent or eduction area of two-thirds the inlet or induction area; a delivery into each small class room opening into large Sunday-school room, and into reading, committee, library and other small rooms, of volumes equal to their cubic contents every seven to ten minutes, and into large Sunday-school rooms every twelve to fifteen minutes, with inlet velocities 400 to 500 feet per minute and vent areas two-thirds to three-fourths the inlet areas.

The vents for main Sunday-school rooms should be located in the main wall between the auditorium and this room and likewise the inlets. It is even permissible when necessary to ventilate the main Sunday-school room by grills or screens and ducts leading under the superintendent's platform. These air deliveries must have corresponding and proper proportions of heating surface, either direct or indirect, for heating the several rooms and parts. The ventilation is given here in terms of air changes in every seven, ten, twelve, fifteen minutes, and the like. These proportions give on the average from 20 to 40 cubic feet of fresh air per minute per person for an average audience. In the event of large crowds on special occasions the plant can be worked harder (if a fan system) and ample ventilation secured.

The plant should always be designed with an allowance in capacity of apparatus for these special occasions. All grills, screens and registers should harmonize in design and color with the finish and decoration of the church.

Taking up the matter of regulation of the air supply, a plant with a double hot and tempered system of air supply with automatic regulation of the mixing of the air is the ideal plant for a church. There should be one common mixing damper for the auditorium, this damper consisting of several divisions—one for each thermostat—and a similar damper for the main Sunday-school room. Each small room should have an independent thermostat and mixing damper, or a hand regulated mixing damper. The thermostats for the large auditorium should be at least two in number and preferably four, and should be suspended from the ceiling. The first floor plan, Fig. 1, and gallery plan, Fig. 2, herewith show these floors respectively of a fan system plant designed along these lines. The basement plan, Fig. 3, shows the fan, heater, tempering coil, fresh

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air apparatus, air ducts, boilers, pump and receiver, engine, steam and return connections, etc., of the same plant as completely as the small scale of the drawing will permit.

The eduction of the vitiated air from the auditorium in this plant is accomplished through vent screens at the sides of the room and with openings from them leading down through the floor to the basement, thence galvanized iron pipes lead over to large vent stacks which in turn lead up to the attic, and being there combined into one lead out through the roof with a globe ventilator on top to prevent down drafts. Fresh air is taken down a stack from a point near the roof, but on the opposite side of the building from the point of emission of the foul air, and the fresh air duct from the base of the fresh air stack is provided with an outer tempering coil, an air washing apparatus, and an inner tempering coil. The outer tempering coil is only used in winter to prevent freezing of the air-washing water. This is, as will be seen, a strictly plenum or pressure plant, the ventilation being accomplished by forcing into the building fresh air, which, in finding exit to make room for incoming air under pressure from the fan, completes the circuit and secures the ventilation. The additional feature of an exhaust fan coupled on to the vent ducts is an excellent one for further increasing the positiveness of the action of the plant, and especially the eduction of vitiated air, but it is not a necessary feature in ordinary cases.

The heater and entire system of air conduits for the chapel, i. e., the Sunday-school part of the building, is independent of the system for the auditorium part—a very essential arrangement—so that for all services when the large auditorium is not used the chapel part of the plant can be economically operated without the whole. The air conduits in the part of the basement utilized for church functions, such as supper room, if in form of overhead galvanized iron ducts, should be made as flat as possible, and to resemble beams, or should be placed underground and made of brick and sewer pipe. The overhead ducts are preferable as to accessibility and less friction and the underground ducts as to least absorption of head room.

A slow speed low pressure steam engine for a maximum of 150 revolutions per minute and ten pounds to 20 pounds boiler pressure, of substantial pattern, to run in oil and with automatic shaft-governor, requiring a minimum of attention, a low pressure automatic pump and receiver for return of condensation to boiler, separate boiler for independent direct steam plant for Sunday-school part and toilets, or for supply of steam for engine in

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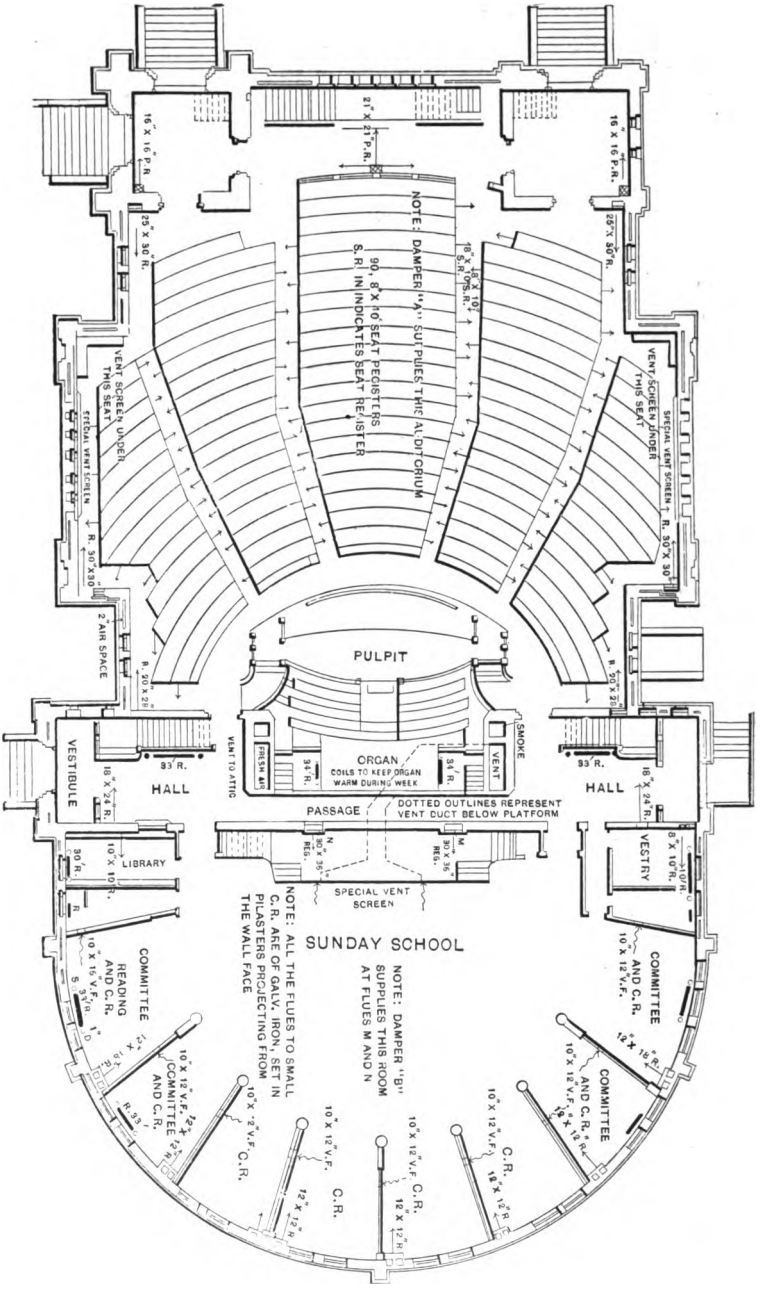

Fig. 21.—FIRST FLOOR PLAN.

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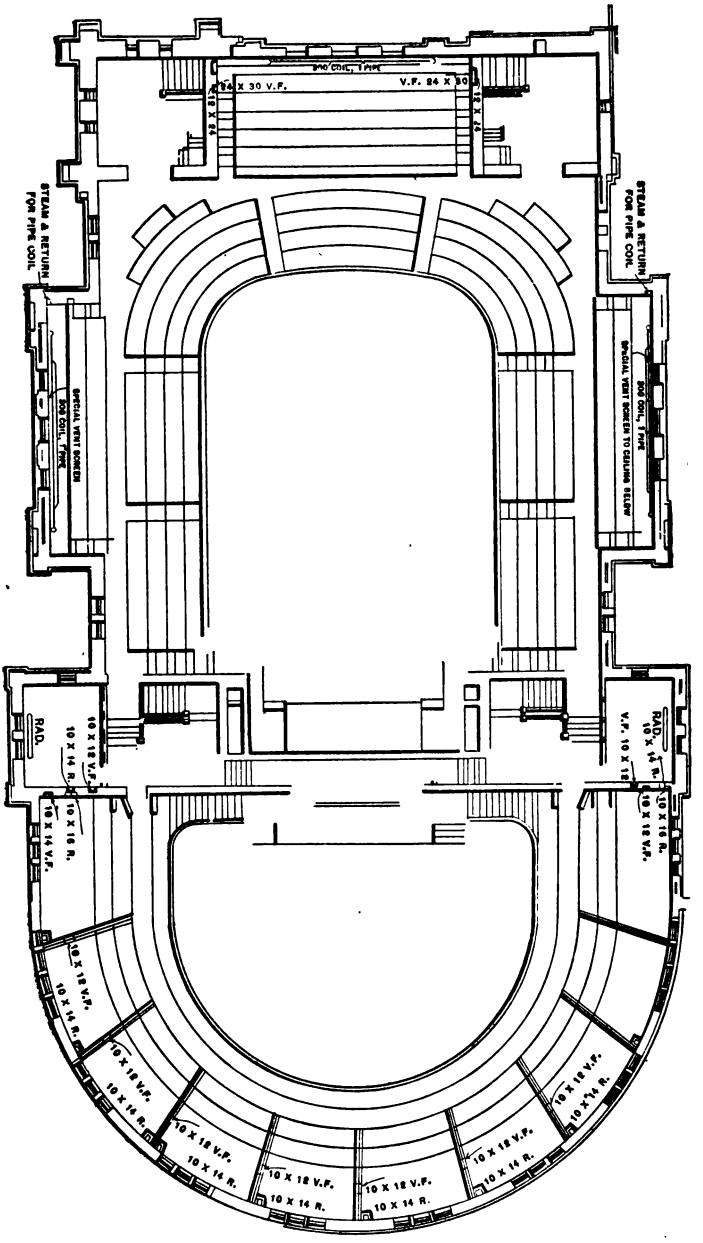

Fig. 22.—GALLERY PLAN.

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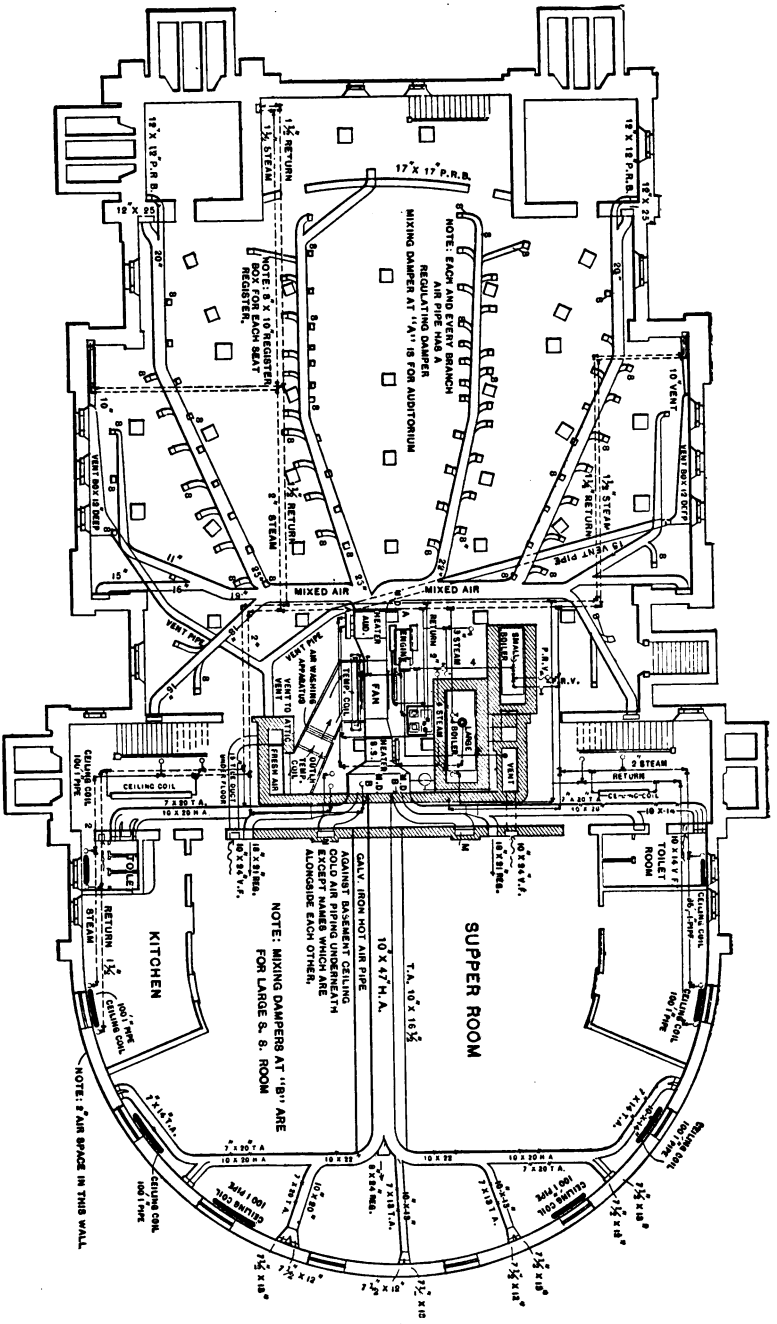

Fig. 23.—BASEMENT PLAN.

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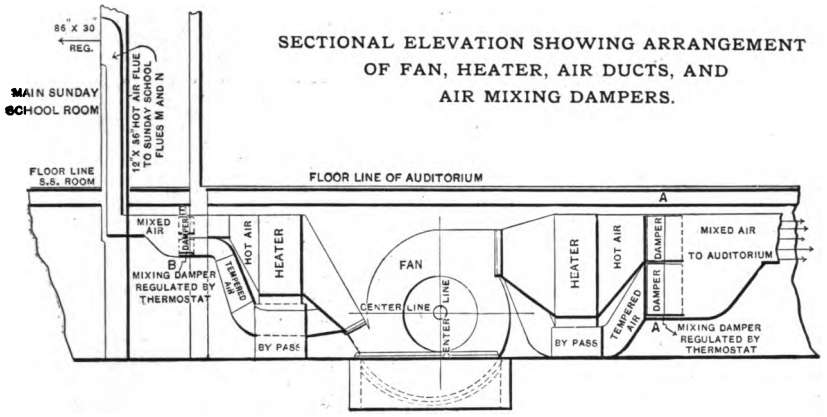
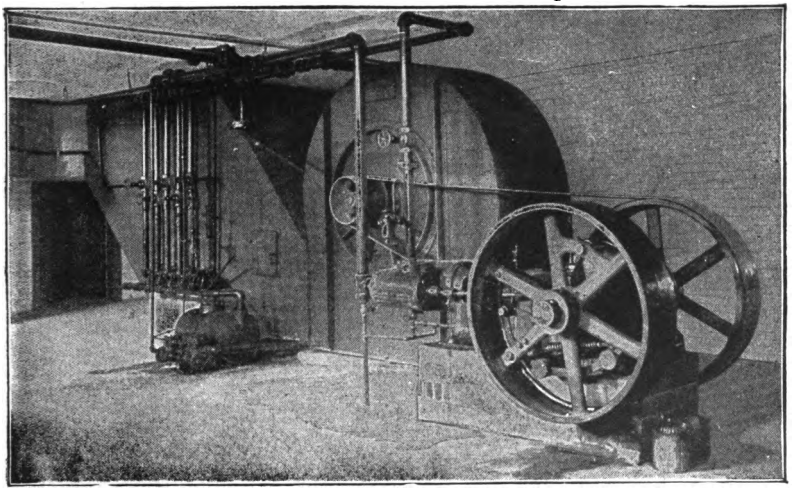
warm weather, a gravity return for the independent direct steam plant when the fan system is not in use, and the system of air ducts form the remaining important features of this plant. A proportion



of one lineal foot of fan heater and tempering coils to five cubic feet of air per minute to be heated forms a proper average ratio for a desired temperature of building of 70 degrees in weather ten degrees below zero, with reduction, of course, for milder and in-



FAN, ENGINE, HEATER, AIR "BY-PASS," WITH HOT AND TEMPERED AIR DUCTS.

crease for more severe conditions, with allowances for differences in exposure, glass surface, and size of dome or lantern. Boiler power should be provided for the severest service of a plant at the rate of at least one horse power (standard multi-tubular boiler

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rating) for every 80 lineal feet of fan heater and additional for direct radiation.

A grease extractor should always be provided on the exhaust pipe of the engine and the exhaust steam utilized in the tempering coils and heaters. The fan, or fans, should be stiffly braced and

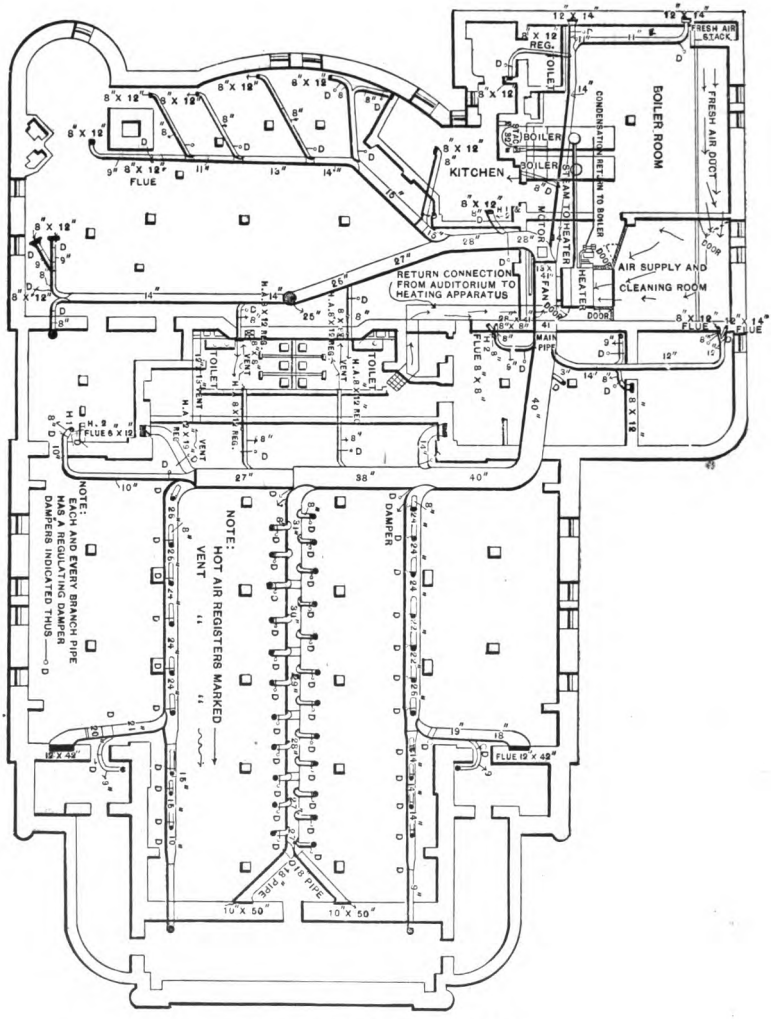

Fig. 24.—BASEMENT PLAN.

should do its maximum work noiselessly and at speed not exceed- in 200 revolutions per minute for large fans and 300 revolutions per minute for small ones. Air velocities in conduits should not exceed 1,800 feet per minute for a maximum initial velocity and

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1,200 per minute for velocities in branch ducts to inlets to rooms. All branch ducts should be expanded for further reduction of velocity near or before reaching connections to inlets to rooms. Each and every branch air duct should have an adjustable regulating damper and all warm and tempered air conduits should be covered with heavy asbestos paper or fire felt. All steam and return connections, except valves, should be properly covered with non-heat conducting covering. There should be provided a canvas connection at least 12 inches long between commencement of main air ducts and heater or fan outlets. In short, all the features essential to make the plant complete and effective in every way should be provided.

The first cost of a plant of this kind should not exceed, on the average, $12 to $15 per every 1,000 cubic feet of cubical contents, and a simple fan system, i. e., a one-pipe plant without double system of hot and tempered air ducts, mixing devices, and automatic regulation should not exceed $10 to $12 for every 1,000 cubic feet of cubical contents. Basement plan, Fig. 4, herewith shows a simple or one-pipe fan system plant. The cost of operation of a plant of this nature should not exceed from six to twelve pounds of coal per square foot of grate surface in boilers per hour on the average or about three to six pounds of coal per hour for each 100 lineal feet of fan heater. The total cost of operation of church plants can only be reckoned from a "cost per hour basis" as hardly two plants will be in use the same length of time. The highways and byways of church heating and ventilating are many and devious, and there is much opportunity for improvement in this line. It should be the aim of the true engineer to secure the best results with minimum cost to his client, not to guess at proportions and then use a large factor of safety, or, properly speaking, "factor of ignorance," and still on the other hand to design plants of ample capacity. Each experience generally teaches us more plainly how much we have yet to learn and gives us valuable lessons to profit by in the design of future equipments, and assists in the achievement of more entire and ultimate success. It is with the earnest desire to add a little to our store of knowledge and to secure profitable discussion and an interchange of views and experience at our annual meeting on the important subject of church heating and ventilating that this paper is presented.

ADDENDUM.

In the matter of the automatic mixing of the air supply for the auditorium, it is essential not only that each thermostat shall in-

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dependently operate a separate division of the large damper, i. e., a small damper, but also that the "mixed air ducts" leading from each sub-division or small damper shall lead independent of all other air ducts to the air inlets, supplying that portion of the auditorium governed by the thermostat operating such small damper; thus, when by reason of change of direction of outside winds, or other cause, one portion of the auditorium is colder or warmer than others, the thermostat in such portion and its respective mixing damper will operate, and warmer or colder air be introduced directly into such part. It is impossible to show all these details in the small scale illustrative diagrams accompanying this paper. It is to prevent any misinterpretation that this statement is added.

DISCUSSION.

Mr. Hugh J. Barron:—Mr. President, there are a number of things in this paper that I think are open to criticism. Mr Prather's idea, of course, is a very valuable one. I should judge that the purport of the paper is to lay out the very best method of heating churches; that is, to approach a standard—an approximate standard for the best method of heating the average American church. There are a number of statements in his paper and a number of things in his drawings that I can hardly agree with. The first thing that you meet with in dealing with a church committee is the commercial aspect of the case. They have not the money to pay for an elaborate apparatus usually; and then there is the question of room. I have a plan here of a plant put in about the year 1888 where all the pipe is underground sewer pipe laid in concrete. That saves the room in the basement. Mr. Prather prefers to get his pipe overhead. In large cities room is so valuable that you cannot get the pipe overhead. It very often does away with a valuable system of ventilating, because the room is too valuable to be appropriated to that purpose. I can see no objection at all to a drain pipe laid in concrete and circling the side of the building with flues communicating from that to the Sunday school (which is usually in the basement) and to the church above. Then there are the eduction fan and eduction flues. I think in ordinary cases they have to be abandoned. Most churches cannot afford to pay for anything of that kind, and I think that is very often why a simpler system is preferred and why there is not more hot blast heating done in church work. The church of which I show these plans, while not a perfect sample of work at all, is a sample of work of which a great deal has been done. It is cheap work. The cubical contents are about 300,000 to

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350,000 cubic feet. The cost is $3,500. That includes everything. I do not believe with Mr. Prather that we should put coils under the windows, because from the commercial side that is not admissible. Eduction flues and eduction fans are not admissible. It must be cheap, and that is the problem that the engineer has to meet.

Mr. B. Harold Carpenter:—Mr. President, there is one point about which I would like to ask if members have had any experience. Mr. Prather speaks of reducing the vent flue. He does not give any reason why the vent flues should be smaller than the inlet flues. It seems to me that unless he uses eduction fans it would be quite as necessary to have the vent flues as large as the inlet. The pressure on the fan gives a pressure in the room at all times. If it is for the purpose of preventing a vacuum and thus preventing the cold air from coming in through window openings or doors, that would not happen unless they had an eduction fan, because if these flues were of the same size, the air would not go out of the vent flues any faster than it came in through the inlet. I see no other reason for his making them any smaller.

Mr. Dean:—That might possibly be because there would be no objection to the air passing faster out of the eduction flues than it came in from the induction flues, his object being to not cause any draft in the house by having the air come in rapidly, allowing it to pass out more rapidly, as it naturally would by having smaller flues.

Mr. Cary:—Mr. Barron spoke of one of the worst things you meet in taking hold of church work or any other work and that is to get your price down, use cheap apparatus, and put it in as cheaply as possible. I think that is rather against the objects of this society. I believe that we are here to educate the public—the steam users—and I think that we should show up the poor plants all we can, bring that before the public, show where there are failures. I do not mean to go where there are personalities at all and criticise people for trade purposes, but I think that if this is the state of affairs—I have not had very much experience in the line of heating and ventilating churches—but if it is, as Mr. Barron says, I think it is something that we want to avoid. We want to educate people to put in good plants and show them that it pays. I do not think we want to throw up our hands and put in cheap heating and ventilating systems which give trouble. I think that is against the objects of the society.

Mr. Fish:—I do not quite agree with Mr. Barron in regard

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to doing cheap work. This paper of Mr. Prather's is certainly a commendable one. His object seems to be to lay before the members the necessity of erecting a better class of apparatus for the successful heating and ventilating of large buildings and churches. The engineer has much to do with the commanding of a fair price for the apparatus he has to design. Some years ago I was in competition for the heating of a very large church. My price was $6,000; another bidder offered to do it for $3,200, but upon comparing the plans and specification, why there was no equality whatever. I furnished a detail plan and specification, while my competitor simply wrote a letter offering to heat the church for so much money, viz. $3,200. I am not an advocate of doing cheap work, and I think that Mr. Prather's paper gives good advice and makes practical suggestions to the engineer to design a good apparatus and one that will be successful in operation, embodying all the best principles of heating and ventilation, and there are many churches which can afford to pay for a good apparatus. I will instance Trinity Church in Boston. Some years ago they paid $15,000 for the heating and ventilating of their church by a hot water apparatus and it was a success. I therefore think the engineer can do much towards getting his contract price when he goes before a committee or board of management by explaining his plans and specifications—to pay him for the installation of a good plant and not try to set up a standard of cheap work. It is true that there are many churches that cannot afford to pay for an elaborate heating and ventilating apparatus, and it is necessary for the engineer to design an inexpensive plant, but I think many churches having well-to-do congregations are looking for the best methods of warming and not the cheapest, and if the engineer will look to that end and advise the committee of the desirability of their having an efficient apparatus, economical and durable, he will in nine cases out of ten succeed in getting a fair price for his plan above that of a cheap competitor. In other words, if he is a skilled engineer and master of his profession and makes a good layout, he will have very little difficulty in having his plan and apparatus adopted. I think this society ought not to set up a standard of cheap work. Let all plans and specifications they recommend be of a high standard, efficient in every particular; in so doing success will surely follow. I think Mr. Prather's paper is a very valuable one and is worthy of commendation by this society.

Mr. B. H. Carpenter:—I am very glad to hear Mr. Barron criticised, as he differed with me in connection with the same question last year.

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Mr. Fish:—I forgot to say that this paper speaks of overhead ducts being preferable as to accessibility and less friction and the underground ducts as to least absorption of head room. Mr. Barron in his remarks did not agree with Mr. Prather in regard to overhead ducts. Perhaps he overlooked the fact that Mr. Prather qualified his statement. There are buildings in which it is perhaps preferable to place ducts overhead, as he suggests, to resemble beams. In some buildings, from lack of head room, you are obliged to place them underneath the ground.

Mr. Newell P. Andrus:—I never had anything to do with church heating, but I would like to hear from some of those made failures of it. I think if we were to hear from those parties we would probably receive some benefit from them.

Mr. Barron:—I would like to meet Mr. Andrus privately some time and tell him all about it. (Laughter).

Mr. Andrus:—That would not benefit the rest.

Mr. Cary:—I will only add a word to what I said before. I think it would be well for some of our members to look up heating and ventilating plants that have been failures and let us have papers on the subject. That is about the only way we will get up to the standard that we are working for. I think, besides showing good work in our papers, we should show bad work as well.

Mr. Connolly:—I think the location of the boiler under the pulpit is a very improper place. I think too much heat centers there. I simply state that to help along the criticisms of this particular paper.

Mr. Fish:—I do not think that criticism a fair one. Probably this church was built before the apparatus was designed and the flue was built in that particular part of the building and the engineer was necessarily compelled to locate his boilers accordingly. That is perhaps a matter that he could not very well help. We have all experienced some difficulty of that sort, i. e., of finding the chimney improperly located, whereas if we had designed the building from the start or built it ourselves, we would have located the chimney in a different part of the building convenient to the boilers. I do not think that this is a point to criticise. The engineer has to deal with the chimney as he finds it and plan accordingly.

Mr. Harvey:—I have had a great deal of experience in heating churches and have had occasion also to look at many that were heated by other firms; and the specifications that Mr. Prather has here I think are very good in every sense of the

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word. The only suggestion that I would mention in reference to the subject is that a great many partial failures have been caused by registers being placed in the vestibules and depending on them for heating, but many of these plants have given good results by putting in a large amount of direct radiation in these vestibules, so that when the doors were opened it warmed the air that came from the outside and prevented the loss of a quantity of warm air, and a much less proportion of cold air was admitted. I think that Mr. Prather is right also about having coils under windows, because I care not how hot the air may be coming into a room through registers, when it strikes a glass surface it immediately cools and produces cold air currents. With the coil under the windows it otherwise heats that glass surface and instead of cooling the air it has the opposite tendency.

Mr. Fish:—I agree with Mr. Harvey and I can now recall a church that I heated many years ago in which I made it my practice to heat the vestibule and passages thoroughly by direct radiation, and I think at these points direct radiation is very essential, especially where doors are constantly opening and closing, admitting large quantities of cold air.

Mr. Connolly:—Mr. Fish stated that heating engineers as a rule, and the engineer in particular who laid out the plan described in Mr. Prather's paper, found the smoke flue located in a certain place and was obliged to locate the boilers accordingly. I should think, judging from the layout, etc., that it was a plan where the heating engineer was consulted before the building of the church, it being a plenum system. I have criticized the plan, as the boiler is directly under the pulpit; I still hold to that criticism, because in connection with it there is a fan and an engine, and of course the congregation would want air on an April or May night, and windows might be closed on account of rain. I claim that if you get up steam on that boiler so located to run engine and fan it would make the minister very uncomfortable. I would like to hear some other members express their views on it.

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XVI.

A DRAFT AND BLAST PRESSURE GAUGE.

BY J. H. KINEALY, ST. LOUIS, MO.

(Member of the Society.)

I have long wanted a draft and blast pressure gauge that would enable me to easily obtain pressure to within 0.01 of an inch of water. After considerable investigating and some experimenting I finally devised the gauge shown to the society, a drawing of which is shown in Fig. 25. Mounted on a board there is a U-tube A in which is placed a quantity of water. To one leg of the U-tube is fastened a 3-way cock H, and to the other is fastened the scale I and the micrometer screw T. The end of the U-tube to which the micrometer screw is fastened is open to the air, so that the pressure in that end is always equal to the atmospheric pressure. The other end of the U-tube is connected, by means of a rubber tube fitting over R, to the place whose pressure it is desired to measure. E is an opening in the 3-way cock H that is open to the atmosphere. By turning the handle of H E and R may be put in connection, R and the U-tube may be put in connection, or E and the U-tube may be put in connection. If R is in connection with the U-tube and E cut out, the water in the left leg of the U-tube will rise or fall according as the pressure to be measured is less or greater than the atmospheric pressure, and the water in the right leg of the U-tube will fall or rise. Both legs of the tube are of the same diameter, so that the

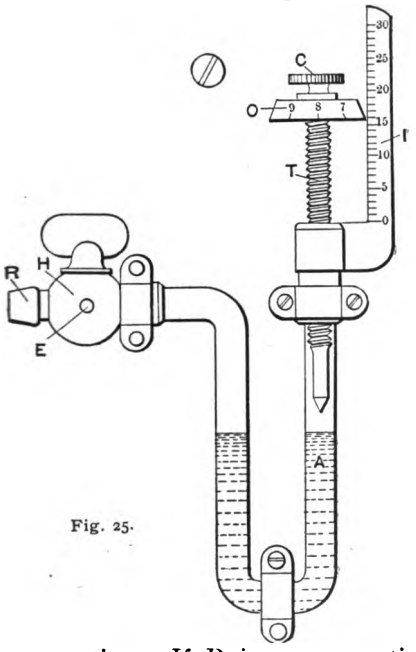

Fig. 25.

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rise or fall will be the same in each, and the difference between the levels of the liquid in the legs will be equal to twice the rise or fall in one leg.

The scale is graduated to tenths of an inch, the micrometer screw T has ten threads to an inch, and the head O is divided into ten equal parts, so that the graduations on the head O represent hundredths of an inch.

To use the instrument, the board on which it is fixed is fastened to a wall or other place of support, so that the legs of the U-tube are vertical; R is connected to the place whose pressure it is desired to measure and the 3-way cock turned so as to connect E with the U-tube and cut out R. The screw T is then turned by means of the milled head C until the point on its end just touches the surface of the water in the U-tube, and the readings of the scale I and head O are taken. Next, the 3-way cock is turned so that the U-tube is in connection with R and E is cut out, and the screw T is run down or up, as the case may be, until the point is again just in contact with the surface of the liquid. The readings of the scale I and head O are again taken. The difference between the first and the last readings of the scale I and the head O give the rise or fall of the water in the right leg of the U-tube, and this multiplied by two will give the pressure of the blast or draft in inches of water.

I have found by experiments that there is no trouble in determining when the point of the screw T touches the surface of the water and in reading the scale and micrometer head to .003 of an inch, although I seldom take a reading closer than .005 of an inch. The end of the screw must be kept slightly oiled so that a drop of water will not gather on it.

In the gauge which I show the society the U-tube is made of a glass tube whose internal diameter is $\frac{3}{8}$ of an inch. I have found, however, that this is not large enough to prevent the interference of capillary attraction. If one of the legs is dirtier than the other, there is a marked difference in the capillary attraction; and to get absolutely correct results, I find that the tube should be made larger. I think it should be about $\frac{3}{4}$ of an inch internal diameter.

The glass work has not been very well done in the gauge which I show the society, and therefore the range of pressure wth which the gauge can be used is not as great as it should be.

It is evident that if the gauge is to be used only to measure the pressure of blasts of fans the scale could be graduated to tenths of an ounce and the micrometer head to hundredths of an ounce.

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DISCUSSION.

Prof. Carpenter:—I am interested in this gauge which Prof. Kinealy has shown, as I think it excellent. I have, however, been using for the past year a gauge of a somewhat different type, which I will take pleasure in showing later. It reads as close as Prof. Kinealy's gauge, and is adapted for use as an anemometer as well as gauge, so that it can be used not only for measuring pressures but velocities of air. On the train last night I unfortunately stepped on the glass portion of the tube and broke it. I left the gauge at a shop to be repaired, but it will be up here this afternoon. If the discussion can be taken up later, I should like to show it to the society.

Mr. Cary:—I have seen Prof. Carpenter's instrument and I am very much pleased with it, but while this matter is under discussion I might show a type which I have used. (Mr. Cary then made a sketch on the blackboard of the instrument to which he referred. This gauge was first described by Mr. J. C. Hoadley in a report of a series of trials of a warm blast apparatus, which was published in Vol. VI. of the transactions of the American Society of Mechanical Engineers, from which the following description of the gauge is taken.)

"Two glass tubes (Fig. 26), about 30 inches long, about 0.4 inch diameter inside and 0.7 inch outside, are connected at each end by means of stuffing boxes, to suitable brass attachments through which they are secured to a backing of wood.

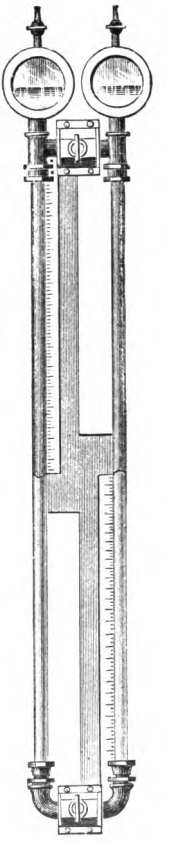

Fig. 26.

These attachments, at top and bottom, have each a tubular opening, with a stop-cock in the middle of its length, which can be turned at will to establish a free communication between the glass tubes, or to shut off all communication. Directly over each tube a brass drum-shaped vessel is placed, 4.25 inches in length and of equal diameter. The heads of these drums, at both ends, are formed of plate glass, properly secured with screw-rings and made tight with suitable packing. A tubular opening extends up from each glass tube to the drum above it, and there is a hole in each drum, directly in line with the axis of the glass tube, each fitted with a stop-cock and nipple for attaching a flexible pipe. Two sliding scales are arranged between the glass tubes to measure.

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one the depressions, the other elevations of the surface of a liquid filling the lower half the tubes, indicated in the cut, (Fig. 26), near the middle of the height. Both stop-cocks are represented in the cut as closed.

"The lower one being opened the two tubes, in communication at their lower ends, are filled up to about the middle of their height with a mixture of alcohol and water, care being taken to avoid wetting the interior of the upper end of the tube poured through, the pouring being done through a small glass tube inserted through the hole at the top of the drum, from which the stop-cock is removed for this purpose. The filling-tube is now to be raised so that its lower end is a little above the surface of the alcohol and water, the lower stop-cock is to be closed, and the upper one opened, and crude olive oil is to be carefully poured in until it fills the first tube up to the upper cross-tube into the second tube, and so finally fills both tubes and rises to about the middle of both drums.

"The crude olive oil is of an olive-green color and forms with the colorless alcohol and water a beautiful and very deep meniscus, if the tubes are clean and the filling has been done with sufficient care, making the line of demarkation very distinct. Neither liquid discolors the glass, and if up-and-down motions are made cautiously and slowly, the liquids do not mix and the common surfaces remain undisturbed. The specific gravity of the oil should be determined in advance, as it may vary a little, although it has been found quite uniformly 0.916. The specific gravity of the alcohol and water may be made anything desired between that of water, 1.000, and that absolute alcohol, 0.813, but must always be made greater than that of olive oil.

"Where extreme delicacy is desired the difference may be as small as one per cent; that is, if the oil be as above, .916, the mixture of alcohol may be .926. If the difference be much less than one per cent, the upper and lower liquids have a tendency to get into confusion and do not constantly maintain a distinct line of demarkation at their common surface. For many purposes a difference of specific gravity as great as two per cent will give sufficient sensitiveness—fifty times as much range as a water column and is more convenient to use.

"The method of using this instrument to ascertain the force of chimney draft or other air current is as follows: If both the stop-cocks between the tubes are opened and both the small stop-cocks on the top of the drums are also opened, so that the surface of the oil in both drums alike is open to the air, both liquids will come to a level; the oil in the drums, very obviously, and the heavier mixture

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below the oil as certainly, if not quite as obviously; since, if higher in one tube than in the other, the united weight of the two liquids in that tube must be greater than in the other and must cause the liquid to sink down and flow into the other tube, raising the surface of the oil in the drum over that other tube and causing it to flow across to the first tube, until both liquids are brought to a coincident height in the two tubes.

"A slight difference will, however, commonly be found in the height of the lower liquid, owing to the unequal capillarity of the tubes, since these can rarely be obtained sufficiently near alike in caliber to avoid, when in equilibrium, a small, but sensible difference of level, which must be ascertained and allowed for.

"If, now, the upper stop-cock between the tubes be closed, the lower one being left open, the surfaces of the two liquids will retain their respective heights in the two tubes, so long as the surface of the oil in the two drums remains subject to equal pressure. But if one drum be put in communication with a flue or chimney, by means of a flexible or other tube connected with the nipple of the small stop-cock—this stop-cock being open—while the other drum remains open to the air through its open stop-cock, the diminished pressure, due to chimney draft, upon the surface of the oil in that drum, will cause the oil to flow up into the drum under the preponderating weight of the air on the surface of the oil in the other drum.

"The surface of the oil in the drum is about 100 times as large as the inside cross section of the glass tubes, and in the same proportion will the rise of the lower liquid on the one side and its depression on the other exceed the corresponding rise and depression of the upper surface of the oil.

"If now, when equilibrium has been restored, the lower stop-cock be closed and the upper one opened and the connection with flue or chimney be severed, say, by removing the flexible tube from the nipple, the lower liquid will be kept immovable, while the oil will flow through the upper cross-tube, and come to a common level in the two drums. On connecting the nipple again with the flue or chimney, and again closing the upper stop-cock and opening the lower one, a diminished repetition of the former action will take place; the lower liquid will rise a little in one tube and fall a little in the other, and the surface level of the oil in the two drums will again become slightly unequal. This inequality, which will be much less than before, may be again removed by the same method; and a very few repetitions of this process will bring the difference in level of the surface of the lower liquid in the two tubes (corrected

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for inequality of capillary attraction, as explained above), to represent the entire difference in pressure on the surface of the oil in the two drums, due to the draft of the chimney; that is, a certain known height of column, filled, in one tube with a mixture of alcohol and water of specific gravity 0.926, with the flue pressure resting on its surface, is just balanced by an equal height filled with olive oil of specific gravity 0.916, with the pressure of the atmosphere resting on its surface. The differential column, therefore, represents a water column one-hundredth part as high, or a column of mercury $\frac{1}{1360}$ part as high. A draft which would be measured by 0.01 inch of mercury, or by 0.136 inch of water, would, on this anemometer, be measured by 13.5 inches of differential column. It is therefore a hundred times as sensitive as a water column and more than 1,300 times as sensitive as a mercury column. If too sensitive, so that the required range would exceed the limits of the instrument its sensitiveness can be reduced to any desired extent by a larger admixture of water, or by the use of pure water, as described by Welsbach, in which latter case the difference of specific gravity will be 1.000 — 0.916 = 0.084, and the sensitiveness 11.9 times as great as that of water alone and 160 times as great as that of a mercury column."

Prof. Carpenter:—There are some objections to this gauge in use. You have to know very accurately the relative specific gravity of the two liquids used. While it gives sufficiently accurate results for measurements such as Mr. Cary has spoken of, if very close measurements are desired, it will hardly compete with the instrument Prof. Kinealy has shown here.

Mr. Cary:—I quite agree with Prof. Carpenter. I much prefer the other instrument. It is much simpler to use. In making a boiler test I have my two bottles with me, one of colored alcohol and the other oil, besides the glass draft gauge, and something is very apt to break, and the pouring in of the two liquids and pouring them out into the separate bottles afterwards, though it can be done easily, is a nuisance, and it is not got at as easily as this. But I have found it very satisfactory. The instrument itself I got directly from Mr. Barrus, and he calculated it very carefully from a regular U tube. It is calibrated under ordinary temperatures in connection with the U tubes. By taking a series of tubes you get a multiple effect carefully calibrated, and then the multiplication is noted on the back of the gauge, so that for each one-tenth of an inch on the scale you merely multiply it by this factor and you get the results directly. The other instrument, though, I regard as very much simpler, and one which I would prefer to use.

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Prof. Carpenter:—This (exhibiting a gauge) is the draft gauge which was unfortunately broken this morning and which I have had repaired. I will explain the principle of it, then show how it can be used. In one form, Fig. *27*, it is an ordinary draft or pressure gauge It has an advantage over most gauges in the fact that one single reading gives the result. It may be described as follows:

The accompanying cut, Fig. *27*, shows the gauge one-half size. The form of the draught gauge is U-shaped and consists of the following parts: The U glass tube B D, air cock C for hose connection, cup A, guides G and F, vertical scale I, which is divided into inch, half, quarter and one-twentieth of an inch, screw K for adjusting index pointer O and having twenty threads to the inch; the index wheel is divided into twenty-five parts, and the whole combination is raised and lowered by screw E; S serves as a protection for glass tube and bearing for E.

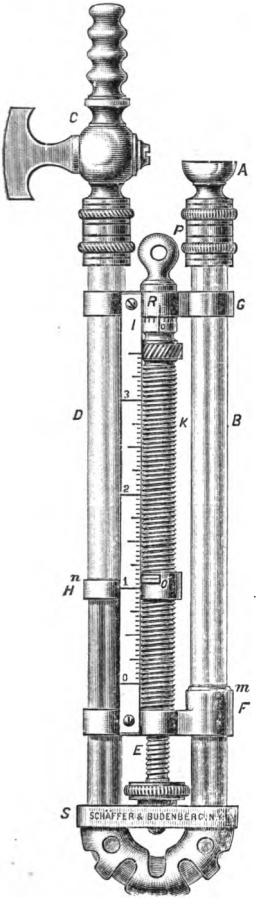

Fig. 27.

Since the screw K has twenty threads to an inch, and the scale is divided into $\frac{1}{20}$ of one inch, then for one turn of K it moves index O one division, and since the index wheel has twenty-five divisions, each division is then equal to $\frac{1}{25}$ of $\frac{1}{20} = \frac{1}{500} = .002$. For example if second division to the right of zero on the index wheel were placed on R, it would then be read $1 + \frac{2}{20} + (\frac{1}{500} \times 2) = 1 + 0.1 + .004 = 1.104$; i. e., each small division on scale I is equal to 0.5, and on index wheel equal to .002.

The method of operation as a draft gauge is as follows: The glass tube is filled with water to about one-third its height, one end of a flexible rubber tube is then connected to cock C, and the other end is inserted to the chimney flue. B is then open to the atmosphere and D is in communication with chimney flue. There will now be a difference of water level in tubes B D. Adjust m so that it will be tangent to bottom of meniscus by screw E, and n by means of screw K. If it is desirable, cock C can be closed and the difference of water level maintained and taken to some convenience place to read.

This gauge can be read very closely, and the difference of height in both gauges is given by a single reading and without reduction.

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In using the draft gauge as an anemometer, for measurements of the velocity of the air, the two branches of the draft guage are connected respectively to two tubes, one of which, as D in Fig. 28, is straight and has an open end which is placed perpendicular to the axis of the pipe in which the air is passing whose veloctiy is to be measured. The other tube is bent so that the opening directly faces the current of moving air. Both these tubes for convenience are inserted in a larger tube, as shown by the section on A B. The current of air blowing in the mouth of the tube P depresses the water in the draft gauge, say to M′, and from one branch of the U tube and raises it a corresponding amount in the other. The pressure in the opening D is communicated by the connecting tube

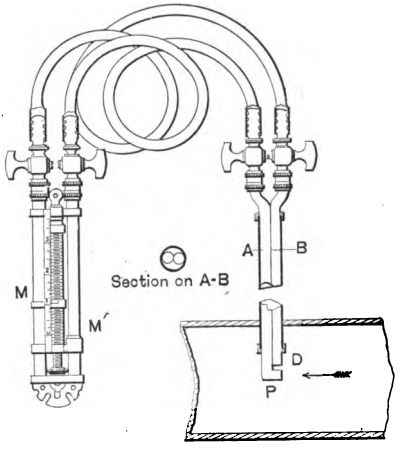

Fig. 28.

to the other branch of the gauge and since this pressure acts the same in both tubes, the effect on the draft gauge is the same as though no pressure existed, the difference in the height in the two branches being due entirely to the velocity of the moving air. This device is an old one and is a modification of an instrument known as Pitot's tube.

In the use of this tube it is necessary that the opening P shall squarely face the current of moving air and that the opening D shall be in a plane at right angles. There being no motion in the tubes P and D communicating pressure to the gauge, there is no correction for friction, and the velocity of the air will be that given by the formula $v = k\sqrt{2gh}$. If water be used in the draft gauge and h be taken in inches, the value of v or the velocity in feet per seconds is $v = 70\sqrt{h}$ when the air is at a temperature of 120

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degrees. If the air is at other temperatures this result must be multiplied by the following factors:

Temp. Air Deg. F.	Factor	Temp. Air Deg. F.	Factor
32°	0.92	100°	0.985
60°	0.95	120°	1.00
80°	0.965	150°	1.05

The diagram, Fig. 29, presents a graphical method of obtaining the results respectively on the left and right. Thus if the scale read-

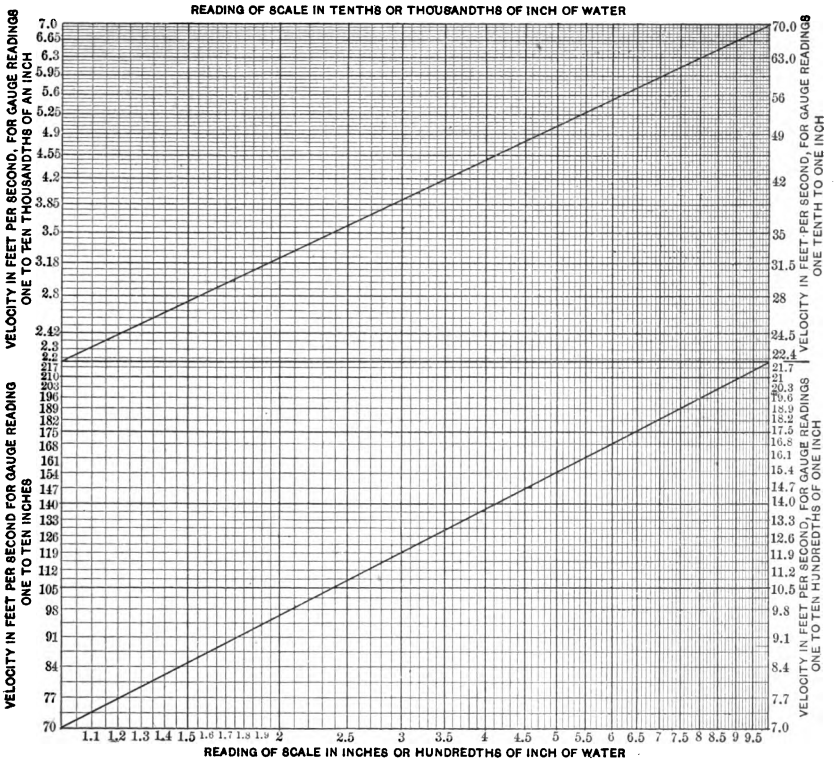

Fig. 29.

has four scales, there being two on each side. If the scale reads between one and ten inches of water or between one and ten hundredths of an inch of water the lower scales are to be used, reading the results respectively on the left and right. Thus if th scale reading is 3.2 inches, the corresponding velocity is 126 feet per second;

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if the scale reading is .32 of an inch the corresponding velocity is 12.6 feet per second. The scales in the upper part of the diagram are to be used in a similar manner when the readings are between one-tenth and one inch and also between one-thousandth and ten-thousandths of an inch. Thus, if the reading in the water gauge is 0.36 inches the velocity is 42 feet per second; if the reading were .0036, the velocity would be 4.2 feet per second.

The description of this instrument is a digression from the subject of the paper and a longer description would be inappropriate in this place. A more complete description of the method of using this as a substitute for an anemometer will be taken up more fully at a later meeting.

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XVII.

METHODS OF INSULATING UNDERGROUND SYSTEMS OF STEAM PIPING.

(BY R. C. CARPENTER, ITHACA, N. Y.)

(Member of the Society.)

The following paper states in a concise way the results of the writer's experience with several methods of protecting systems of steam piping which are laid underground. The paper does not pretend to be a compendium of all the methods which have been used for this purpose, but simply contains a description of those which have come under the writer's observation.

There are, in a general way, two methods of insulating pipes, when used to convey steam long distances underground; these may be specified as the tunnel system and the trench system.

In the tunnel system a conduit lined with brick or masonry of sufficient size for the pipes and for a person to enter for examination or repairs is constructed. In this the pipes are carried on suitable hangers and then wrapped with some insulating substances or covering. A sufficient number of expansion joints or equivalents are used to prevent injury to the line by expansion due to heating and cooling. While this system possesses many advantages over the trench system and is usually to be preferred, its cost is so great as to be in many cases simply prohibitive and some method of trench construction is necessary.

The first system of underground steam piping which the writer saw constructed was put in about 1879. This system was about one-half of a mile in length and was intended to convey high pressure steam for operating a steam pump which was located at about that distance from the boiler. The system was constructed in a very crude manner, very little attention being paid either to the effects of expansion or to protecting the pipe from surface water from the soil. In constructing the line a deep trench was dug, the steam pipe was screwed together, and joints of wooden pump log was placed over the steam pipe for insulation. The trench was then back filled.

The line was used for the purpose intended for three or four

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years, but it was not at any time considered a success. The surface water at times covered the pipe, so that large masses of steam apepared at the man-hole; several breaks were also caused by expansion and contraction. After three or four years of use expansion joints were put into the pipe and a tile drain was laid by its side to remove the surface water. It was then used successfully for some years afterwards, in fact as long as it was needed.

The next system was constructed in 1880 under the general directions of the writer. This system had a total length, including

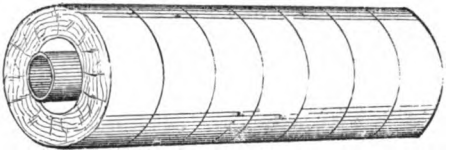
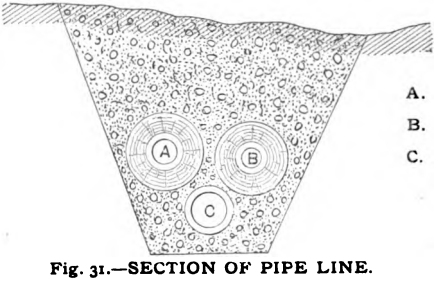


Fig. 30.—PIPE WITH WOODEN TUBE INSULATION.

branches, of about one mile, and consisted of two independent lines of trenches, each containing main steam and return pipe. This system was used to convey the steam for heating purposes from a central boiler plant to a number of buildings belonging to the same public institution. The method of construction was very similar to that used at that time for conveying steam from central boiler plants through the streets of a city for heating purposes. For these special lines very careful surveys were made, and the line was laid with a continual descent from the buildings to be heated to the boiler house. After the trench was constructed a drain of 6-inch tile, such as is used for farm drainage was constructed, so as to be about six inches lower than the steam pipe lines. The



A. STEAM MAIN.
B. RETURN MAIN.
C. DRAIN.

Fig. 31.—SECTION OF PIPE LINE.

steam pipe lines were insulated from heat loss by a wooden tube with a shell four inches in thickness. The diameter of the tube was two inches greater than that of the pipe and the pipe was held in a central position by iron collars. The tube joints were made by driving a tenon on one end of the pipe into a mortise on the other end of the adjacent pipe.

The wooden tubes which were used for this purpose were made

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by special machinery out of large pine logs. The tubes were eight feet in length. The logs from which they were made were first placed in a large lathe and the external circumference shaved off by a knife the full length of the pipe. This operation required a great deal of power and sometimes the logs broke during the process of turning, in which case they were thrown with great force against the sides of the building. After the logs were turned to the proper size they were then bored, the auger for this purpose being a tube which cut away enough wood only to make clearance sufficient for its own motion. The core which was cut out from the interior log could be bored in a similar way with a smaller auger and thus form smaller pipes without loss of timber. After the pipes had been turned and bored they were then placed in a lathe and strongly wound with a hoop-iron, arranged in a spiral form. This added very much to the bursting strength. They were then rolled in hot tar and covered with a coating of saw-dust. Before the pipes were finished the ends were bored out for a short distance to form the mortise joint, and a short tube, which was allowed to project about six inches was placed in one end to form the tenon. These pipes made in this way would withstand considerable water pressure, and many successful systems of water works have such pipes in use.

In the system described double expansion joints were placed at distances of 240 feet and man-holes were left at these points for inspection and for the repair of the joints.

The expansion joint used was somewhat heavier than that ordinarily sold and was provided with an inside lug, so that under no condition could the parts of the joint pull entirely apart.

The wooden logs which were used for insulating purposes were very badly charred in five years from the date of laying and contained a great many season checks, so that water could freely run from the soil onto the pipes. This reduced the efficiency of the line in a great measure.

This line was anchored in each man-hole midway between the two expansion joints, and although steam was turned off every night at ten o'clock and on again every morning at six, no leaks whatever were ever traceable to this cause.

This line is still in use, and for the first ten years after its construction did not require any repairs or any expenditures whatever, except such as related to the annual inspection and repacking of the expansion joints.

The system next described was constructed in 1885 and in this both main steam and return pipe were used, the return pipe being

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laid in the center of the main steam, so that the pipes were concentric. The outer pipe was wrapped with asbestos and over the entire system a tube of sewer pipe was laid. The lengths of sewer pipe were split longitudinally, the upper half being put in place after the steam pipes were in position, the joints being protected by concrete.

This system has proved very successful in use and is still in service. The expense of running the return pipe in the center of the main steam is considerable and while it tends to prevent all heat losses from the return is very difficult to construct. With this system the water would be received into the boiler at the temperature of the steam, and the work of the boiler would be simply to evaporate water into steam of the same temperature. The heat used in the building would be essentially that which is given out in the condensation of steam without change in temperature, the entire losses being those due to radiation from the steam main. Except for the difficulties of construction the system is perfect.

A system of underground steam piping was constructed by the writer in 1878, in which both main and return pipes were laid in a wooden box covered with concrete. The pipes were supported on suitable hangers and provided with proper expansion joints and were loosely wrapped in coverings of sheet asbestos and hair-felt. A drain was laid underneath the trench to carry away the soil water. The general method of construction is shown in Fig. 32 and was as follows: After excavating the trench a layer of concrete four inches in thickness was then spread over the bottom and was made about six inches wider than the box to contain the pipes. The box, which was made of pine plank, was slipped in place without top and in sections. The pipe hangers were then put in place and the steam and return pipes laid. These pipes were then tested for leaks, then wrapped with the covering, as described. The top of the box was then put in place and the whole box surrounded on top and sides with a layer of concrete four inches in thickness.

This system has proved successful and has superior insulating powers to any of those previously described. In the pipe systems protected with the wood pipe, sufficient heat escapes in practice to thaw any snow which falls on top of the ground. Our experience with the construction described, through several severe winters has shown that the ground is not thawed nor is the snow melted; this would indicate that the heat loss is quite small, as the snow is melted with a very slight escape of heat.

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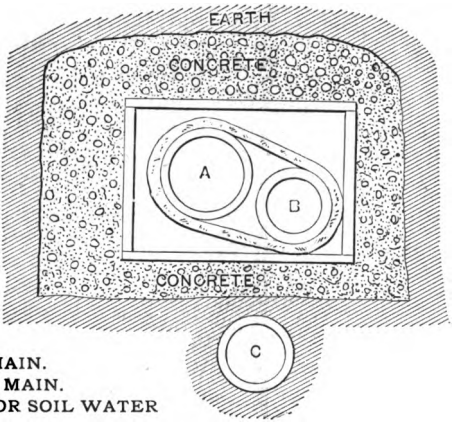
The cost of the latter construction is much less than that of the wood pipe system of insulation.

The writer believes that an improvement in the system described could be made by supporting the pipes by hangers resting on the concrete; this would add much to its permanency. Wood used in underground construction of this character rots very soon, and if it is used in such a manner as to form an essential part of the support of the pipe line, its decay may affect the alignment of the whole system and in that way interfere with the economic operation. Wood is, however, a very excellent insulating substance and would no doubt be useful for such purposes for a long time after its power of supporting the pipe had been lessened by decay or by carbonization.

The buildings of Cornell University were heated with steam, which passes through a system of underground piping, in 1888



A. STEAM MAIN.
B. RETURN MAIN.
C. DRAIN FOR SOIL WATER

Fig. 32.

In the system first used the boilers were situated in a building near the highest part of the campus and but little of the return water could flow back by gravity. Consequently no attempt was made to return the water of condensation, except from the group of buildings immediately surrounding the boilers. In most of the buildings the return water was passed through a large cooling coil placed in a ventilating shaft and as much heat as possible was extracted in warming the air used in ventilation. In this system the expansion of the pipe lines was taken up by variators constructed by the Holley Mfg. Co. In the variator one end of the pipe was supported by a movable diaphragm and the expansion and contraction of the pipe was compensated for by motion of this diaphragm. These were placed at intervals of about 50 feet along

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the line. They were very simple in construction and as they have no stuffing boxes they are supposed to require no attention. As a matter of fact, however, they did not prove to be durable for the particular service to which this line was subjected. The alternate heating and cooling seemed to render the diaphragms brittle and they gave out frequently.

The insulation of this line was not very satisfactory; this, added to the fact that the water of condensation was largely lost, which involved a loss of heat estimated at eight to ten per cent in excess of that from radiation, led the board of trustees to consider the reconstruction of the line with a boiler house so located that the water of condensation would return by gravity to a tank or well from which it could be pumped while hot to the boilers. Such a system was constructed in 1894 by Mr. Andrew Harvey of Detroit. In the reconstructed system the method of insultation adopted was, first, a sewer pipe laid concentric with the steam pipe and inside a wooden tube similar to that first described. Heavy expansion joints placed at distances of about 200 feet were used to take up the

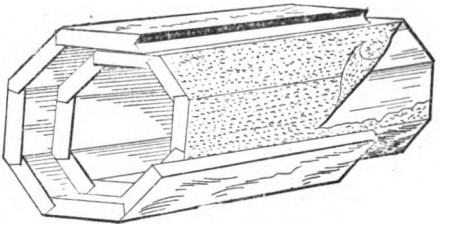

Fig. 33.—WYKOFF BUILT-UP WOOD TUBING.

expansion. This system has now been in use two winters and has proved to be of good mechanical construction. The heat insulating properties are not, however, superior to those of the old system which it replaced. The wooden pipes laid in 1886 and taken out in 1893, having been in use seven years, were in every case badly charred. Weather checks extended from the center to the outside and soil water could easily reach the main pipes. In both systems of pipe construction at Cornell University the question of soil drainage has been neglected with the result that a good deal of trouble and great loss of heat is frequently occasioned by water flowing onto the hot steam pipes.

The writer measured at one time the loss of heat in a pipe line at South Plainfield, N. J., which I believe was constructed by one of the honorable members of our society for the purpose of conveying steam for power purposes from a boiler plant to several engines situated at considerable distance from the boiler. In this case the insulation was obtained by using the Wyckoff wood cov-

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ering. This covering consisted of two thicknesses of inch board with tarred paper between, so laid as to break joints and form an octagonal pipe as shown in the sketch. This pipe, in the opinion of the writer is much superior to the solid wood pipe, since it is less likely to check and crack. In this case, however, the

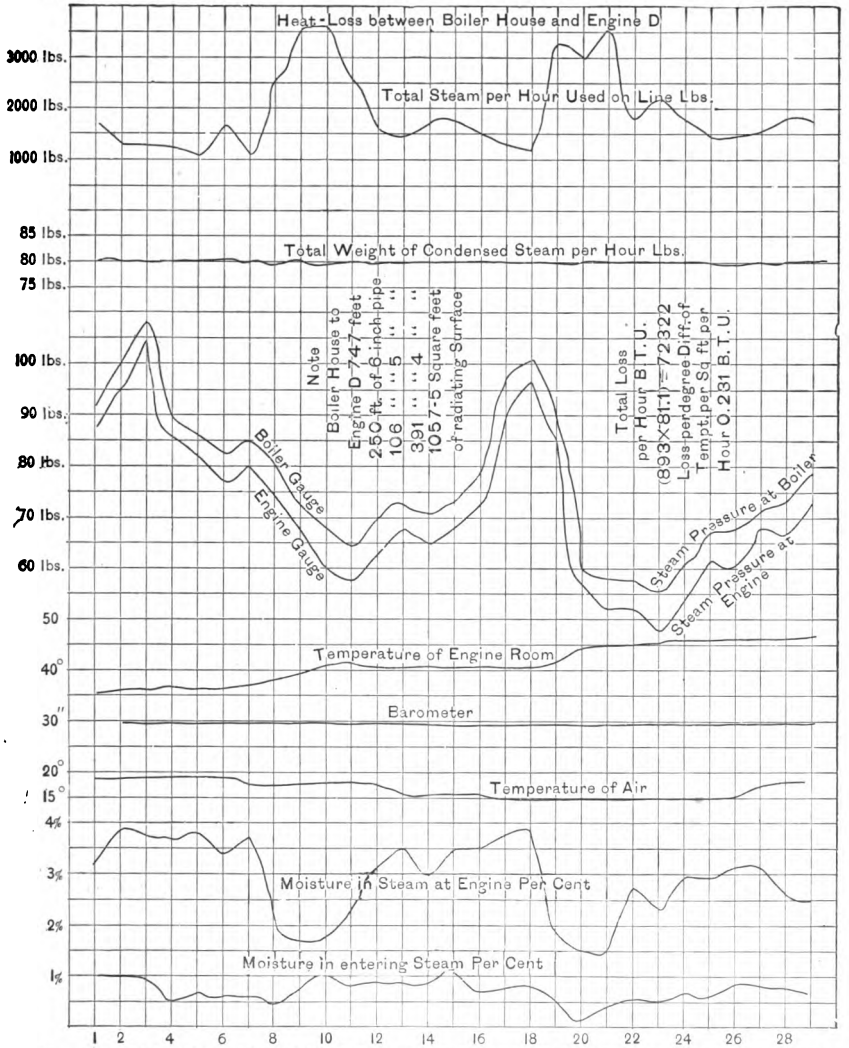

Fig. 34.—DIAGRAM SHOWING RESULTS OF TESTS TO DETERMINE HEAT LOSSES IN UNDERGROUND PIPE AT SOUTH PLAINFIELD, N. J.

pipe was not buried under ground, but the whole was inclosed in a large plank box partly filled with saw-dust and placed on top of the ground. No expansion joints were used nor were collars employed to keep the pipe in the center of the wood casing. The

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ground in that locality was very swampy, and wet, and it would have been impossible to keep it dry, so the location of the pipe was the best possible under the circumstances. The results of the test showed that the loss of heat was comparatively small, and in this respect the covering was satisfactory. The writer has been informed that the line has since been reconstructed. The result of this test is shown clearly in Fig. 34.

Various other systems of insulation have no doubt been used with greater or less success. The writer is of the opinion, however, that whatever system is adopted the important points to be considered are in every case as follows: first, protection of the pipe from surface water (it should be remembered that evaporation of water from the outside of the pipe is accompanied by the condensation of an equal amount of steam); second, provision for taking up the expansion and keeping the pipe line in proper alignment; and third, insulation of the pipe from heat losses. It is the writer's opinion that no matter what system of construction is adopted, means should always be provided for thoroughly draining the soil.

The simple slip joint, when made sufficiently heavy and when thoroughly anchored, seems to provide for expansion and contraction very well. It needs, however, occasional inspection and repacking. A swinging joint has been used in some systems with success. On account of the bends in the pipe it produces some additional friction and slight loss of head. It also changes the lateral alignment to a greater or less extent and cannot be erected in as narrow a space as the straight line with expansion joints.

The loss of heat depends entirely upon the insulation which is provided for the pipe. With the best quality of insulation the loss can be reduced to about 15 per cent of that from a bare pipe in still air. Tests of various insulating substances as taken from a table in a recent work by the author on "Heating and Ventilating Buildings" gives the results which may be expected in a very convenient form. It should be noted, however, in every case that the loss from a naked pipe is dependent principally upon the temperature of the steam and is independent of the velocity of the steam in the pipe. Under ordinary conditions the condensation loss from a naked pipe in still air is about one-third of a pound of steam or about 320 heat units. This amount is increased by motion of the air, the results being substantially as shown in Fig. 35. It seems most convenient to refer all steam coverings to the bore of the pipe as a standard, and this method was adopted in the table quoted. It will be noticed that with some coverings having fairly

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good conducting power the loss of heat increases with increase of thickness. This is due to the fact that an increase of thickness is accompanied by an increase in surface; if the heat passes readily

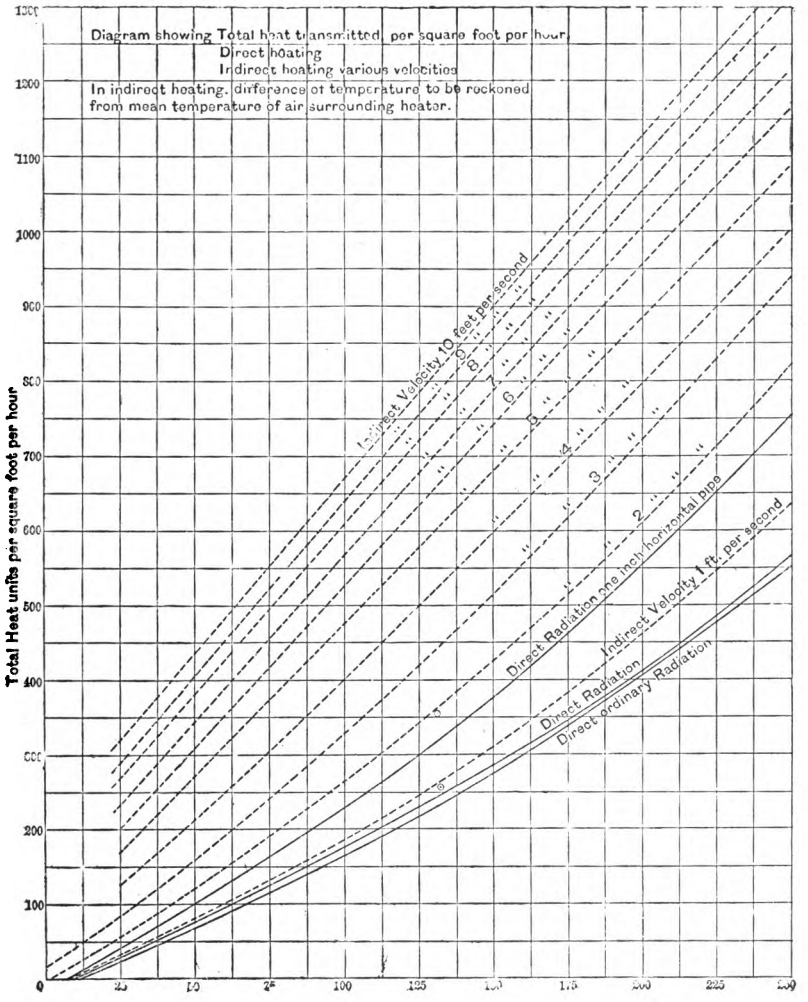

Fig. 35.—LOSS OF HEAT FROM PIPES IN AIR UNDER VARIOUS CONDITIONS.

through the covering the amount it gives off will depend largely on the nature of the surface and as this is increased the conducting power also increases.

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The following gives results of tests of various pipe-coverings made at Sibley College, Cornell University.*

Kind of Covering.	Relative amount of heat transmitted.
Naked pipe	100.
Two layers asbestos paper, 1 in. hair felt, and canvas cover	15.2
Two layers asbestos paper, 1 in. hair felt, canvas cover, wrapped with manilla paper	15.
Two layers asbestos paper, 1 in. hair felt	17.
Hair felt sectional covering, asbestos lined	18.6
One thickness asbestos board	59.4
Four thicknesses asbestos paper	50.3
Two layers asbestos paper	77.7
Wool felt, asbestos lined	23.1
Wool felt with air spaces, asbestos lined	19.7
Wool felt, plaster paris lined	25.9
Asbestos molded with plaster paris	31.8
Asbestos felted, pure long fiber	20.1
Asbestos and sponge	18.8
Asbestos and wool felt	20.8
Magnesia, molded	22.4
Magnesia, sectional	18.8
Mineral wool sectional	19.3
Rock wool, fibrous	20.3
Rock wool, felted	20.9
Fossil meal, molded, ¾ inch thick	29.7
Pipe painted with black asphaltum	103.5
Pipe painted with light drab lead paint	106.7
Pipe protected by wood tube, 3 feet earth	32.0
Pipe protected by Wyckoff tube, 3 feet earth	18.0

The following table translated from Péclets Traite de la Chaleur gives in a general way the amount of heat transmitted through coverings of various kinds and of different thicknesses; the loss from a naked pipe is taken as 100.

PERCENTAGE LOSS OF HEAT FOR VARIOUS PIPE COVERINGS.

Relative Conductivity.	Thickness, in inches.							Kind of Covering.
	0.4	0.8	1.0	1.6	2.0	4.0	6.0	
	Relative Conducting Power.							
0.04	29	20	18	13	11	7	6	Eider down, loose wool, hair
0.08	43	32	29	23	20	13	11	Powdered Charcoal. [felt, etc.
0.16	56	48	45	38	35	25	22	Wood.
0.32	66	63	62	58	55	44	41	Sand.
0.64	73	75	73	77	78	70	68	Clayey earth.
1.28	77	83	85	92	96	102	109	Stone, rock.
2.56	78	87	91	103	110	130	150	White marble.
5.12	79	90	95	109	118	149	180	Solid gas carbon.
10.00	100	100	100	100	100	100	100	Naked, or unprotected surface

*From Heating and Ventilating Buildings, John Wiley & Sons, New York.

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DISCUSSION.

Mr. Cary:—This matter of the value of placing pipes underground and the amount of heat that you get at the other end of the pipe is one of a good deal of interest. I know a large company in this city who are supplying steam over quite a large area. The president and secretary of the company asked me at one time for information on this very subject. They had looked in every direction. They had found in a number of places what purported to be information, but they found it to be useless. It was founded on theory, or somebody's idea on the subject and was of no real value at all. This placing of pipes underground and conducting steam from central stations, I believe, is a practice that will become general before very long. The New York Steam Co. has made a success of it now in New York. They started off with no experience. They have been through a great deal of experimenting and have paid very dearly for it, but fortunately they had capital enough to carry through their experiments, so that we now very seldom have blow-outs in the streets. They have it under control. Reading, Pa., and other towns have been encouraged to put in similar plants. There are a great many plants where a great deal of steam is wasted, especially the exhaust steam from the engines, and there is one case in which they have tried to utilize that, and it has been very profitable; that is the Brooklyn Edison light station. There they take their exhaust steam from their engines, run it through pipes covering quite a little territory in their immeditae vicinity, heat one or two theaters and office buildings, and it has been quite profitable. It has put a little more back pressure on their engines and of course they are burning a little more coal than they would if they merely ran their engines without trying to utilize the exhaust steam. But I believe that a good many large plants that are now throwing away exhaust steam, that are in the neighborhood of office buildings, apartment houses, and other buildings requiring heat, will soon come to that system and this matter of running pipes underground and finding the best methods for protecting pipes will come to the surface. It is coming to the surface every day. The loss of heat from uncovered steam pipes seems to be a subject that has attracted a good deal of attention lately. This matter was brought up by Mr. Brill at the Detroit meeting of the American Society of Mechanical Engineers. There was a very interesting paper read there by him in which he went into an exhaustive survey of experiments to get at the relative value of the different coverings. Prof. Carpenter re-

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ferred to it and it may be found in the transactions of the American Society of Mechanical Engineers, and it might pay those who are interested to look it up. The method of getting at this is taken from the paper published by the Hartford Steam Boiler & Insurance Co. through "The Locomtive." It gives a very good idea of the subject. It is found in the September number in the year 1892, and that may be interesting to those who are looking into the matter.

There is one point in this paper (pages 121 and 122) where Prof. Carpenter speaks of placing the two pipes concentric—the main steam pipe and the return pipe. That is a very neat way to decrease the size of the trench to insulate the pipes, but I question whether it is good practice. If they could do the reverse—put the steam pipe inside and the exhaust pipe outside—of course you would get your larger pipe your return pipe, which would be wrong of course. But the return pipe should incline toward the boiler and the steam pipe should incline in the direction in which the steam is running. I have found in my experience that when I tried to tip a pipe up so that the water would run back to the boiler after leaving it, and the steam run along in the opposite direction, there is always water running along the bottom of the steam pipes, and it would have a tendency to take that out and overflow the surface in a similar manner to the wind striking the surface of the water in a river. It takes it up and carries moisture to the heating system, which is not desirable. That would be overcome by placing the two pipes concentric with one another. It was a very ingenious way to place them.

Mr. Clark:—I have had a little experience with this system of heating, having had charge of the plant in Lebanon, Pa., for four years. We have had all these troubles that Prof. Carpenter mentions in his paper. We have had a great deal of trouble with the surface water. At times in wet seasons people would come to our office and tell us we had leaks at certain places in our steam main. It was nothing more or less than the surface water getting down in the variators. The variators are bricked up. The pipe is laid exactly as given in his paper, in wooden logs, but the variators are bricked up, and we could never keep out the surface water.

In one place that I now have in mind the pipe is not over two feet under the surface, so that when you get your variator bricked up, you only have about six inches of earth on top of the brick work, and it is a very easy matter in rainy weather for the water to get down into the variator and we had a great deal of loss from condensation in that way. In regard to the wood log,

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I have taken up wood log that had been down four or five years that seemed to be as good as when put in. In other places it had been charred and carbonated so that it would fall to pieces with a very slight rap on it. The exhaust steam we tried. We ran our plant three years with live steam and it cost us 62½ per cent of our income. We meter the steam with a Holly meter. It cost us 62½ per cent of our income, from the meter rates, to operate the plant. We made an arrangement with an electric light company to furnish us exhaust steam—all the exhaust steam that they could furnish, and to supplement the remainder with live steam. We made a contract with them for the first year to furnish it for 33⅓ per cent. Of course that paid the steam company, but it did not pay the electric light company. We made a contract with them the second year for 45 per cent of our income, and this was at the meter rates also. That paid the steam company, and I have every reason to believe that it paid the electric light company. But we had trouble, as the electric light plant was also running an electric railway system. The electric railway laid down nine miles more of track, and then in the very cold weather the electric light plant did not make ample provisions to furnish the steam plant, the electric light plant, and the railway plant, so that when the steam would get down below 80 pounds pressure in their boilers, the steam company was cut off. Of course that caused a dissatisfaction along the whole line. In very cold weather, when we wanted the heat most, we might have it cut off an hour or so. But the exhaust steam worked perfectly satisfactorily to everybody concerned until they put on the extra nine miles of street railway, and I have heard from some of the directors in the electric light plant that it paid them until they took on the extra street railway, and then, of course, the street railway paid them better than the steam plant. They get $6 a day for running the street railway. Exhaust steam has been utilized in Springfield, Ill. It has also been utilized in a great many towns in the West, and we got reports from all over the country before we went into it, and it was demonstrated thoroughly in Lebanon that exhaust steam can be used in that way. I think the proper way to do it would be when you construct an electrie light plant and a steam plant, to construct them at the same time and have one made to fit the other.

Mr. Cary:—I would like to ask Mr. Clark how that exhaust steam was conducted to their customers—whether they had a vacuum system or something of that kind at the other end of it, or whether they depended on the slight back pressure on the engines to carry it through their mains and supply the customers.

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Mr. Clark:—The exhaust was connected direct from the engine into our steam main and connected also into a heater and into the atmosphere, so that if they got too great a back pressure on their engines they could then throw it into the atmosphere, and in mild weather when the consumers would not take the steam they had trouble with back pressure on their engines and then they threw it into the atmosphere. But we had three months in the year during which they heated entirely with exhaust steam and did not have to use any live steam.

Mr. Cary:—I think if a good many of our members would look into the electric stations and others where a large amount of steam is used and the exhaust wasted, it would be very profitable. If any one on a chilly day would look at the Edison station in Pearl street and watch the immense clouds of steam going off from the plant, those who have anything to do with steam would immediately see very big piles of coal disappearing in front of them all the time. I think it is a subject that should be looked into more than it has been and that we should get more information on the subject. I would like to ask Mr. Clark about what pressure he had, about what the length of their pipe is, and about the size. I do not mean to trouble him with too many questions, but I think that is interesting to all of us.

Mr. Clark:—We have a little over a mile and a half of steam main. The boiler house sets about two-thirds of the way, or there is two-thirds of the main distributed in one direction from the boiler house and one-third in the opposite direction, so that we have over three-quarters of a mile from the boiler house to the extreme end of the main. We start out from the boiler house with a 10-inch main, run about 400 feet, which takes us from the boiler house, out an alley, to the main business street in the town. Then we run about six squares east with a 4-inch main, and then it is reduced and we run two squares with a 3-inch main in the opposite direction from the 10-inch main, into an 8-inch main two squares. We branch off from that 8-inch main with a 6-inch and run about eight squares. Then that is reduced again to a 5-inch. We run three squares with that 5-inch. Now where we took off the 6-inch main from the 8-inch, we take the 6-inch from the sides of a cross; at the end of cross, we take a 5-inch and run three squares with that. Then from the opposite side of the cross an 8-inch coming up here we run a 6-inch one way, and we run a 3-inch two squares to the north, and a 5-inch about three squares. We now have about 145 consumers. Most of the steam is con-

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sumed by business blocks. We have some residences, but the majority of the consumption is by hotels, public buildings, and stores. In the coldest winter that we ever had in Lebanon we never had to carry over fifteen pounds pressure, and as a rule we carry ten pounds pressure.

Mr. Cary:—That is the back pressure on the engine?

Mr. Clark:—No. I did not understand the question that way. I thought you asked the pressure we carried on the main when we run our own plant.

Mr. Cary:—You say you took the exhaust steam from the engine. What back pressure was the engine running under?

Mr. Clark:—With the exhaust steam from the engine it got as high as forty pounds back pressure. But in the winter when we were using it, we would have from ten to fifteen pounds back pressure on the engine, or the same amount as we had on our main. On a mild day, before the people would turn on the steam, they would have to turn off the street system pretty quickly or throw it into the atmosphere. I never saw this forty pounds back pressure myself; but the superintendent of the Electric Light Company several times came running up to our place and said he had forty pounds back pressure and that he shut us off. In the boiler house, when we were running our own plant, we ran about fifteen pounds pressure.

Mr. W. M. Mackay:—I would like to know if there is any way of improving on the method Mr. Carpenter suggests, or any way that would help the covering of underground pipes. The matter of heating different cities with steam in different plants would possibly come under discussion, but not under the head of a paper describing underground covering.

Mr. Barron:—I would like to call attention to Prof. Carpenter's description of the insulation of the pipe at Cornell University and to criticise the insulation a little. Prof. Carpenter says that "the heat insulating properties are not, however, superior to those of the old system which it replaced." It seems to me that if Cornell had gone about that in the right way they would have put that pipe in a cast iron casing; that is, in place of building a brick trench and putting a roof over it, such as the steam company does in New York city, use a heavy cast iron square casing with covers, so that the pipe would be accessible, and insulate it with hair felt and canvas, or use, as I used recently, a large water pipe. I had occasion recently to cross a street about 60 feet wide and I put in a 16-inch heavy water pipe that weighed 8,500 pounds. Inside of that we put in a 6-inch steam

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and a 3-inch return pipe. That kind of construction is durable; it lasts forever, and in our case it was easy to put in mineral wool, but in the plant at Cornell you would have to have a system of covers to get at it for repairs. I do not think that the total cost would have been any greater than the system designed here; that is, a system of a concentric tile pipe, and then, concentric with that, a system of wooden pipe. The tile is breakable and the wood is perishable, and I think the system pursued by the New York Steam Company is far superior; that is an ordinary trench dug and filled in with brick and then roofed over with a tight roof; that is, matched boards and on top of that roofing paper and transverse matched boards. Of course, the addition of Prof. Carpenter's drain pipe is a considerable improvement where there is an extensive system of piping, as in most of our universities or in our cities. I think that is one of the most important parts of his paper. Unless Prof. Carpenter had agricultural experience I do not think he would have thought of it.

Prof. Carpenter:—The engineer of this system at Cornell University (Mr. Harvey) is with us to-day, and I think we had better hear from him. I think he can tell why this system was used instead of some other form which has been described as superior. I think Mr. Harvey will say, for reasons stated by Mr. Barron, that the system adopted was not the best possible, but it was the system that was economically the most advantageous to use.

Mr. Harvey:—Mr. President, I think that the paper which Prof. Carpenter has written is in accord with my own experience very largely. Since remodelling the apparatus at Cornell University, I, like others, have found some fault in every job that I have done. I have seen a great many improvements in the same line, but I am satisfied that if the ground had not been all rock at Cornell University, and springs coming through the crevices of those rocks, it would have been easier to have provided for the contingencies that exist there. But those things I was not aware of so much at the time. The last improvement which I have found was a partial combination of Prof. Carpenter's ideas and an idea of my own, and that was to make a hermetically sealed chamber with a sewer crock, with heavy cast iron rings with sockets, so that the socket would form the socket for each sewer crock, and thus were made perfectly tight, so that no water could get into them; and then, instead of the crocks fitting the logs as closely, I had three inches of air space around the outside of the crocks, and that I found a good thing. Other gentlemen have talked about underground pipes. If the financial

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ability of the concern could afford to put in an iron pipe instead of a crock that would be a good thing; but if you can afford the expense I am inclined to think that a good tunnel, large enough to get in to repair or make changes when desired is the best. I put such a tunnel in at the University of Michigan. It was about a mile in all clear around the campus, where you could walk right around it inside. That is a perfect success, because all the joints are easily seen and can be attended to when required. In order to put in a plant of that kind it takes money, but it pays in the end.

Mr. B. H. Carpenter:—I take it that these tests are all made with new coverings. I would like to ask Prof. Carpenter if he has had any experience or made any tests at any time where the coverings have been used, say, five years, and what the relative value of them would be at that time; and whether, taking, say, hair felt, which is perishable, is much or any better during five or ten years, than some of the coverings that do not show as good a test when all are new.

Mr. Andrus:—I had occasion some years ago to put down about 200 feet of 8-inch pipe in a trench, the depth of which was about eight feet to four feet and the fall of the pipe was about a foot in sixteen feet, and we anchored the pipes at both ends with an expansion joint in the center. The pipe was all laid on rollers, so as to allow for a good free movement, and then we built on each side of it, after it was graded up, an 8-inch brick wall, with cement on the outside and a flagstone cap on top, except where the expansion joint was located. The latter was built in a square box so that you could get down to it to pack the joint. It was covered with asbestos plastered on and then on the inside of the wall, on each side of the pipe, there was a roller placed so as to strike the two sides, so as to keep the expansion joint from in any way springing at all, and then after running several years, they found whenever they got down to repack their joint, there did not appear to be any moisture or anything of the kind in any way. It seemed to be very satisfactorily put in. But as to the merits of the covering I could not say, except what was saved by it; they used to get very dry steam at the lower end.

Mr. Cary:—Mr. Barron, speaking of the use of iron pipe, reminds me of an incident in this city that might be interesting. A steam boiler was in the basement of a building on one side of one of our streets. I do not know that it will do for me to say exactly where it was. They wanted to get steam connections across the street. They applied to the city for a permit to take up the street

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and run their steam pipe across, and they were unsuccessful. So they went to a man in the city who makes a business of driving wells. They got him down in the basement and he drove a well right across the street. He was fortunate in not striking any other pipes or conduits or electric light wires or anything. They put the pipe in there, put the steam pipe inside of it, and I believe it is working successfully to-day.

Mr. Payne:—About four years ago I put in a plant. The boiler house stood 400 feet away from the end of the building. The building itself was 400 feet long and the boiler house stood considerably below the building. It was absolutely necessary to run the pipe under ground. It was also necessary to pitch the steam main up from the boiler instead of pitching it towards the steam radiators. We dropped the steam main down about ten feet below the water line, taking care of the condensation in that by means of a steam loop at a point next to the boiler. Then we ran the steam pipe inside a tile pipe split in halves, each section being three feet long. The steam pipe was on rollers, the chairs of which were made to conform with the inner radius of the tile pipe, and there were two projections in the bottom of the chairs which were placed in small excavations made in the tile pipe and then cemented so as to hold them fast. In the center of the run was placed a double expansion joint thoroughly anchored, access to which was had through a brick man-hole. Side by side with the steam main we ran the return for 400 feet and then in through the building 400 feet, and after taking off all the radiation the loss at the end was a pound and a half. We used asbestos sponge covering. The pressure on the boilers, which had been used before for other purposes, was thirty pounds. This pressure was still used, although the circulation could be maintained with considerably less. The steam loop worked very thoroughly, taking care of the water perfectly, and there was apparently no trouble from pitch of pipe. There was no trouble from the surface water in that locality; therefore I cannot say anything regarding that matter. I did not have any opportunity to make any further tests. I merely submit the facts as they are.

Prof. Carpenter:—In answer to three or four questions which have been asked regarding the systems described in this paper, I wish to say that the paper is confined to the description of some of the plants with which I had become personally familiar. Some of them were in my charge for a good many years, one for ten or twelve years, so I became familiar with its behavior under actual use. I consider all of the systems described far indeed from my ideal, especially for con-

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veying steam long distances for public institutions. I think, where underground steam pipes need to be used for public institutions, and such use is likely to be very extensive, that the following requisites are important. First, every portion of the pipe from one end to the other should be accessible for inspection used; I believe that we had better use two pipes, the joint or equivalent area of which is of the proper size, than one pipe for the reason that we are liable to accidents, and if we were to have two pipes, although the total area might not be greater than the area of one, we could by using high pressure steam for a short time get opportunity to repair the broken down pipe. In reply to a question I would not advise iron in the outside casing. It is very expensive, it is not nearly as good a non-conductor as brick or stone, and consequently I think it would cost more money and not be as effective or efficient. The points regarding surface water mentioned in the paper I think will also be found to be of great importance. Regarding the durability of some of the coverings described I would say that I have tested hair felt that has been in use three years and found it deteriorated very much. I have also tested asbestos that has been used four or five years and found no special deterioration. As to the effect of time on the rock and mineral wools I know nothing, although I cannot see why they should be affected.

Mr. Fish:—In what particular did you find the hair felt deteriorate?

Prof. Carpenter:—It becomes very brittle, loses all its elasticity, finally falls off from the pipe and becomes a compact mass. The reason the hair felt is a very poor conductor is that while it is very elastic and the fibers remain apart and it embodies a very large amount of air, it loses its heat-insulating properties after it has been used a long time, when it becomes brittle and hard. Consequently it does not have very long life as a conductor.

Mr. Fish:—Was the hair felt applied to the pipe?

Prof. Carpenter:—No; I have always used asbestos; that is with high pressure steam; although with low pressure steam it has its value.

Mr. Fish:—In covering pipes I have largely used one inch hair felt put on in the usual way. I believe practical tests of the relative value of different pipe coverings conducted in New York by a leading expert show that the best covering is had by first placing a layer of asbestos paper around the pipe, then one inch thickness of hair felt over this, then cover in heavy canvas and

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paint two coats of white paint. I have always found this combination a very durable and effective pipe covering, and it has given me excellent satisfaction in my practice.

Prof. Carpenter:—That is the best on our lines too.

Mr. Jellet:—(Vice-President Mackay in the chair) This discussion is a particularly interesting one, and it deals with a subject that we should all know as much as possible about. I do not know that I can add anything to what has been said, although I have had some experience in this line. The first underground system I had charge of was for heating purposes in a state institution located on the slope of a hill, the distance from boiler house to end of line being in all about 700 feet and the rise in the distance about 107 feet from the boiler house, so that the water would be returning in the opposite direction from that in which the steam was travelling necessarily. We used the plain Wyckoff covering, simply dug a trench and filled the lower part of it with broken stone. On that we laid the Wyckoff covering. The first run was to what is known as the teachers' building, the expansion being taken up in that building. We then crossed a public road and entered two main buildings, and we took up expansion at these points. Then up the hill to the schoolhouse, and in that last run we had a rise of about 47 feet in 150. This plant has been in use constantly for about six years. It is used simply for heating the buildings and for warming water in the buildings. It is a state orphan asylum. They have never carried over five pounds pressure in the boiler room, and in the coldest weather we have three and a half pounds pressure on the radiator at the end of the line. The whole plant was a cheap plant. The instruction given in preparing the plant was that the cost should be minimized; that there was an appropriation of $6,000 which must build the boiler house and warm the five buildings. The results attained, considering the conditions under which it was done, are very satisfactory. The percentage of loss is quite small. There has never been any failure of the system and we had no particular trouble with charring of the logs.

The next plant that I had to do with was referred to in the paper under discussion. It is at South Plainfield, New Jersey. This particular plant is in connection with the Dodge conveyor system for storing and handling coal, and the necessities of the case there required that the plant should be cheap, the object being to carry steam to engines located at various points from the boilers and to run those engines at intermediate times for the unloading and reloading of the cars with coal. The plans were

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made from drawings furnished by the railroad company before they bought the property. The distance is 1400 or 1500 feet in both directions from the boiler house. I found water 12 inches below the surface over the entire ground and I declined to put the pipes in under these conditions. The matter was referred to the consulting engineer of the company, who recommended that they drive piles and carry it overhead, using cast iron boxes on top of the piles to hold the conveyor box. The insulation was put on to protect the pipes sufficiently and give the engines reasonably dry steam. There was no special economy in operation aimed at, because the use of the plant is so varied; one day a particular engine will have no use whatever, or four of them may be running at once. The boilers selected by the company were vertical tubular boilers, and I think the chances of getting wet steam are much greater in that form of boiler than in a great many others. This steam piping was put in in a plain wooden box. Inside of that we used the Wyckoff log covering and we filled the box with sawdust between the Wyckoff covering and the outer box and coated the whole thing with tar, sloping the roof of the box to drain off water. There are no expansion joints on the line, the expansion being taken up by offsets. Professor Carpenter has given the results of this method of conveying steam, which, on the whole, considering the conditions, have been very satisfactory.

I then put in a plant in a College building, using terra cotta drain pipe. The entire length of the run was 700 feet, of which 200 feet were underground. We used terra cotta pipe and inclined the bells of the pipe in the opposite direction following the grade of the ground. That is, the surface water would follow the incline of the pipe itself beyond the bells and not return in the bells. We simply used the terra cotta pipes as a cheap method and filled them with loose magnesia. As section by section was placed over the steam pipe it was practically packed with loose magnesia and the joint of the terra cotta pipe was calked afterwards. We have never had any complaints. This has been in use five years and we are running an engine 700 feet away from the boiler house. We carry about fifty pounds of steam on the boiler and I found forty-seven on the gauge at the engine, so that the loss is comparatively light, considering the conditions.

In reference to the matter of piping at the University of Pennsylvania, there they have a main tunnel from the central boiler house which connects the larger buildings. In the tunnel they have two main supply pipes, one arranged as a winter pipe and

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the other as a summer pipe. But they are connected in each building and are interchangeable. Prof. Carpenter refers to this as being a good arrangement to provide for accidents. This pipe passes through the tunnel to the college building, from that to the medical building, then to dental hall and the tunnel is continuous between these points. Certain other buildings are heated by pipes run in trenches under ground. In the last connection we put in for the university we used a new method which has been very satisfactory. We took the steam pipe, hung it in expansion hangers in a wooden box, which was filled with a non-conducting covering; in this particular case we are using mineral wool. The wooden box which encloses this covering is then suspended in a much larger box, and the space between the inner and the outer box is filled with concrete, a very good grade of Portland cement being used. The inner box rests on chairs, so that the concrete could pass under as well as fill the side and the top. The rods on which the roller rests pass through the inner and the outer box so that in case of the box rotting away, the concrete supports the insulation. It is a permanent thing and the distance of that run is some 300 feet, the expansion being taken at the end, a relief pipe being also inserted. We have all pipes in the same trench and the boxes side by side, carrying high pressure supply and exhaust through the building, the two being entirely separate. We have recently put in another plant where the question of cost had to be more carefully considered, and I have taken a size larger of a section of covering, placed it over my steam pipe, placed my pipe on rollers and concreted the whole thing, concreting the covering as well. I had to keep away from water. It was on the slope of a hill where there was a constant wash and they had no money to put in a proper trench. So we put a system of this kind in and tested it and we have found no trouble as yet. Of course it has only been in use some two or three months and we cannot tell what the results will be, but I have every reason to hope that the concrete will keep the water out. We tested it very carefully before we covered in the trench and we found that we had no trouble whatever with expansion. The run is some 380 feet. There are no joints whatever in the pipe other than sockets. It is a straight line; only there is a rise from the boiler house to the buildings of some eighteen feet.

The question of carrying the water in the direction in which the steam is going cannot often be done in institution work, because the boiler is almost always placed at a lower part of the ground and frequently that is the least desirable place for the better class

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of buildings for college purposes. We frequently carry the pipe on a line offset and drop to allow for expansion and relieve. The experience we have had on underground pipe has been that in no case has the loss exceeded five per cent. We have used various coverings, we have used magnesia, we have used the Wyckoff log, we have used loose magnesia and terra cotta pipes, and we have used the inner covering of Wyckoff, and filling in the space with sawdust, and we have found that the variation has been three to five per cent on the average system. I think there is a great deal to learn yet in underground piping; but the point that we have to look at in systems of this kind is to keep the water out, provide for expansion, and minimize the loss, and we are frequently asked to do that at a minimum of cost. Therefore, no one system can meet all the conditions plus the last condition of cost.

Mr. Quay:—I think nearly all of these remarks are excuses for first cost. I surely agree with Prof. Carpenter in referring to the conduit system in the first part of his paper, and I think there are several reasons why this is the only system that should be adopted for underground work. It is not the steam pipe alone that is to be taken care of. We find that the electric wires and the water pipes also have to be taken care of. Ann Arbor University called on different engineers to submit plans and specifications for heating their buildings. Some of the engineers recommended the Wyckoff. Others recommended the tunnel system. One reason given for recommending the tunnel was that the electric wires and water pipes could be placed in the same tunnel. Of course the first cost is more, but when you consider the expense of repairing, of adding branches to the main line to heat other buildings, which is often the case, and also the difference in the life of pipes that are properly taken care of and of those that are not, I think that we would be very safe in recommending a good tunnel for all systems of this kind. I do not like the idea of having to make excuses for the first cost of a job of any kind. Of course we have to consider the matter of investment—whether it is going to pay from a financial standpoint; whether you can save enough in the economy of running the apparatus and the expense of repairing to pay the interest of the investment for the first cost. It is usually the cheap jobs that are the most expensive before you get through with them. I do not think there is any question but that a good tunnel of sufficient size for a man not only to pass through and examine the pipes, but to work in so that he can make repairs at any time in any kind of weather is the proper thing to advocate.

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Prof. Carpenter:—I agree with Mr. Quay very thoroughly in some respects. But I do not agree with the general principle he has enunciated. It seems to me that whether we put in one system or another depends largely on the interest on the investment. Take the case in question of that of constructing the underground pipe line at Cornell University as an example. You will see how the matter stands. I know just about what we lose daily by poor insulation by our present system. It costs just about three tons of coal per day to meet the loss of heat by our present system. Now that coal costs us $1.80 a ton delivered in our station; so you can see how it costs about $5.40 per day, or about $700 per year. Now if we had the tunnel system and a better system of insulation, I am sure we could have reduced that cost one-half. We could have brought the loss down to $300 a year I am quite certain, and we could have made a saving of $400 a year; but to have put in the tunnel system would have cost us about $30,000 more than the other system did, so that we would have had an outlay of $30,000 to save a running expense of about $400, and you can see at once that it is a better investment to take the poorer system and build it over when it gives out.

Mr. Albert A. Cary:—In putting in underground work there is one point that has not been touched upon, and that is looking out for repairs. Within the last six weeks or so in a building uptown they had a great deal of trouble with water coming up through the cellar floor. Somebody had gone in there and put down six inches of solid concrete and the important pipe ran under this concrete. It gave out. The plant was shut down and they had to go through six inches of concrete before they could get the pipe up, and the people in the house were pretty cold before they got through. That is a thing that wants to be looked at. In putting down a plant of this kind, when it is new it is all right; it operates well and you may test it as much as you want to; but it will deteriorate and you cannot always find all faults in applying the ordinary tests, and in putting down trenches or anything of that kind and putting pipes in them. If the pipe can be made so that a break can be made at certain distances and maybe a pipe pulled out, if it went through into the next conduit, and so worked out, or some other method for making repairs be provided, I think it would be a much more preferable plan, and that should not be overlooked in designing a system.

Mr. Harvey:—I think Prof. Carpenter hit the nail on the head when he mentioned that fact because both he and I spent some time in considering that very question before the last plant was

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put in, and it just amounts to this in a great many cases—a man may get a coat for $60 and he can get one for $6; the question is should he go without one altogether if he does not care to invest so large an amount, or would it not be better to take the $6 coat? That is practically the situation. Is it better for an institution to have forty or fifty separate boiler plants just because they would have to renew the protection of their underground pipe once in ten or perhaps twelve years? They can afford to do it and renew that every five years and still save a good interest on their investment.

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XVIII.

FORCED BLAST WARMING WITH FURNACES.

BY GEO. W. KRAMER, NEW YORK.

(Non-member of the Society. Presented to the Society on request.)

No new principle is involved in the use of a furnace to warm the air of a building. Neither is there anything novel in the movement or distribution of air through ducts by means of a fan, yet natural as the combination of the two may seem, there are comparatively few instances where this has been successfully accomplished.

My experience in connection with the installation of several systems of this character will probably explain why I have been requested to submit a paper on this subject, wherein I should state the reasons for, the results of, and the conclusions deduced from, placing apparatus in the combination heretofore referred to.

A brief prefatory explanation is essential prior to making this statement. In my practice as an architect I have planned buildings located in over one-half of the states of the Union, thus becoming familiar with and meeting the various climatic as well as other local conditions, such as exposure, protection, materials, construction and character as well as the prejudices and preferences peculiar to the clientele.

All systems of heating, by steam, hot water and hot air have been utilized, in combination with the various methods of securing ventilation. In this I have had no prejudices, preferences, fads, or hobbies, but freely used what I deemed best adapted to each individual case.

As a specialist in ecclesiastical work I have had in recent years more to do with churches than any other class of buildings. The peculiar conditions, which are probably more complex than pertain to any other class, should first be considered.

The modern church consists generally of two auditoriums, one, the church proper, the other, the Sunday-school. These auditoriums are quite frequently arranged so as to be combined or thrown together. The Sunday-school consists of a number of subordinate apartments, also arranged for separation or combination. In

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addition there are generally various other apartments of a subordinate character. Nine-tenths of the churches are used as a whole but one day of the week. The periods of use vary from two to three hours at a session, generally a short session in one portion then in the other, frequently using the two auditoriums in combination, and occasionally using the entire building. This generally occurs during the most severe weather. Ventilation is most essential when the most adverse conditions prevail. Thus, there are ever varying conditions to this most complex problem and each application must be solved in accord with the governing conditions.

The apparatus must be efficient and sufficient, noiseless, combine safety and simplicity with economy, both of first cost and maintenance, automatic in operation (or as nearly so as possible), as brains cannot be incorporated and are seldom employed to operate or care for the building or apparatus. A uniform temperature and plenty of fresh air must be secured and the building must be quickly heated and controlled under always varying conditions.

For the larger and better class of churches, where continuous fires are maintained, and skilled employes in charge, no better system can be devised than indirect steam or hot water in connection with mechanical propulsion of air, all properly and scientifically installed.

Direct steam or hot water should not be used, except for halls, corridors, lobbies, etc., as no perfect system of ventilation can be combined with direct radiation. With many, a prejudice exists against placing a boiler with the necessary, pipes, valves, pumps, traps, feeders, and consequent paraphernalia in the church, all of which bewilder the average mind as being very complicated; that damages arising from carelessness, leaks, freezing, etc., in connection with the necessary repairs frequently cost more than the maintenance, to say nothing of an occasional explosion.

Thus for the majority of churches this would leave the so-called hot air furnace as the only recourse. The limited distance to which heated air can be conveyed by gravity necessitates in the complicated modern church a distribution of apparatus, fuel, and pipes that practically render the basement useless for other purposes. Satisfactory, continuous and controllable ventilation is difficult if not impossible.

The necessity for utilizing the various possible apartments of the basement, suggests the concentration of apparatus. A central location for the apparatus is essential to equalize the distribution.

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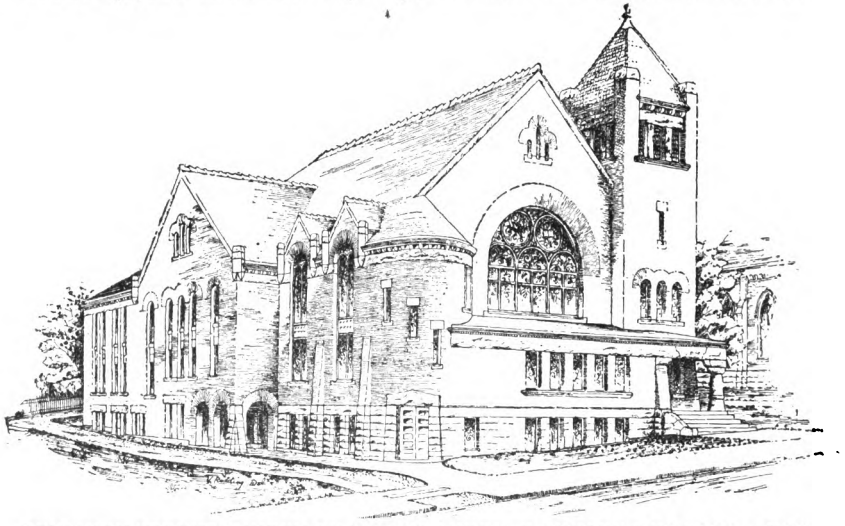
The large distributing ducts, placed necessarily at an elevation, prove as objectionable as the distribution of apparatus, atmospheric conditions often rendering them inoperative, when their services are most required.

The application of the fan suggests itself, with a concentration of apparatus in a portion of the building least required for other purposes, using smaller and concealed conduits. On investigation I ascertained that this combination was considered impracticable, but could find no existing example as evidence that this condemnation was other than opinion based on untried theories or prejudices without foundation. Previous experience was not of such a character as to lead me to place implicit confidence in theories, many of which operate most successfully when reversed; consequently I determined to make a test for my own satisfaction.

An opportunity soon offered. Having at that time a church of about 250,000 cubic feet capacity, in which I was free to introduce



NEW HIGH STREET CHURCH OF CHRIST, AKRON, O. WEARY & KRAMER, AR'TS.

any system I desired, results being the only condition, I concluded to make the experiment, having no doubt of success in some degree.

Having no precedent to guide, all supply, distribution, and installation was calculated on the same basis on which we install a blast system using steam, substituting warm air furnaces for the steam heating coils, however. For the purpose of equalizing pressure, distribution, and temperature, I arranged for much larger reservoirs.

I desired to secure a furnace which I thought competent to do

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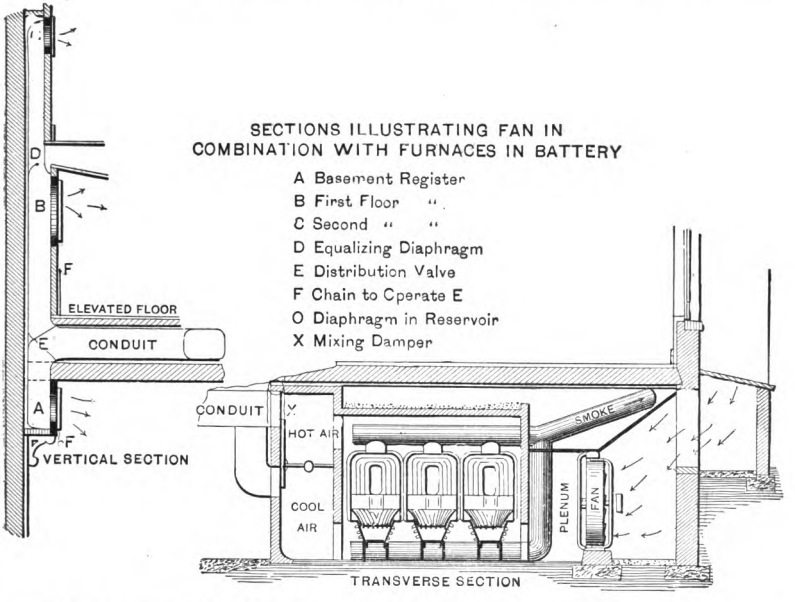
the work, and in which a proper amount of grate surface was combined with a great amount of so-called radiating surface. Calculating from a steam basis I could ascertain the grate surface necessary to produce the heat, reasoning that the same amount of fire should do the same work.

I knew from experience that from one-third to one-fourth the radiating surface in connection with the fan, as compared with direct radiation in steam practice, would produce the same results. Would the same relative condition prevail in the use of the furnace? I could not secure a furnace with sufficient radiating surface, without getting nearly double the grate surface necessary; no one would guarantee their furnace to heat air at the desired velocity; I was advised that natural law determined the velocity at which air



could absorb heat, that I could not circumvent or improve on nature; in short the various conflicting opinions and advice offered would make interesting reading as compared with the results obtained; I reasoned that the same natural laws that governed the heating of air passing over the steam coils at a velocity of 1000 feet per minute would apply; that air would absorb more heat in passing over a properly constructed furnace on account of the higher temperature.

Manufacturers of the best furnaces considered, estimated that not less than four to six furnaces would be required to do the work and then doubted the results.

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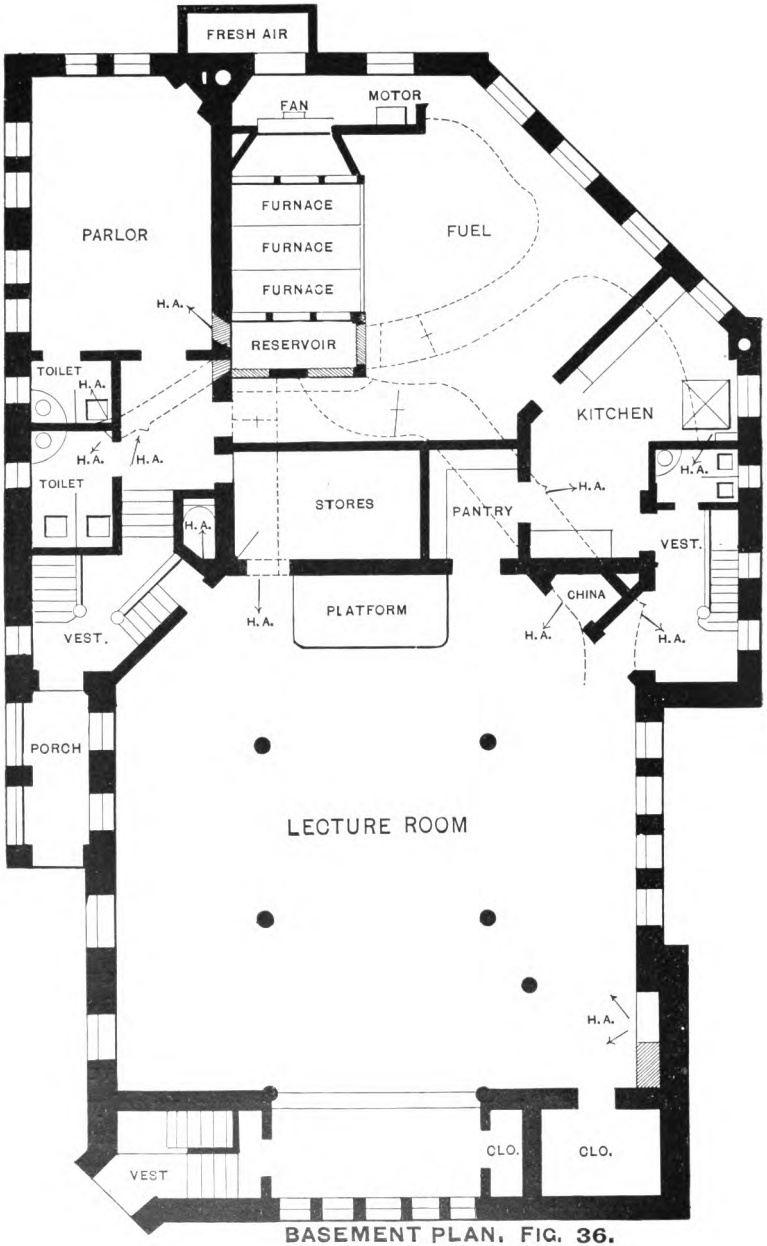

BASEMENT PLAN. FIG. 36.

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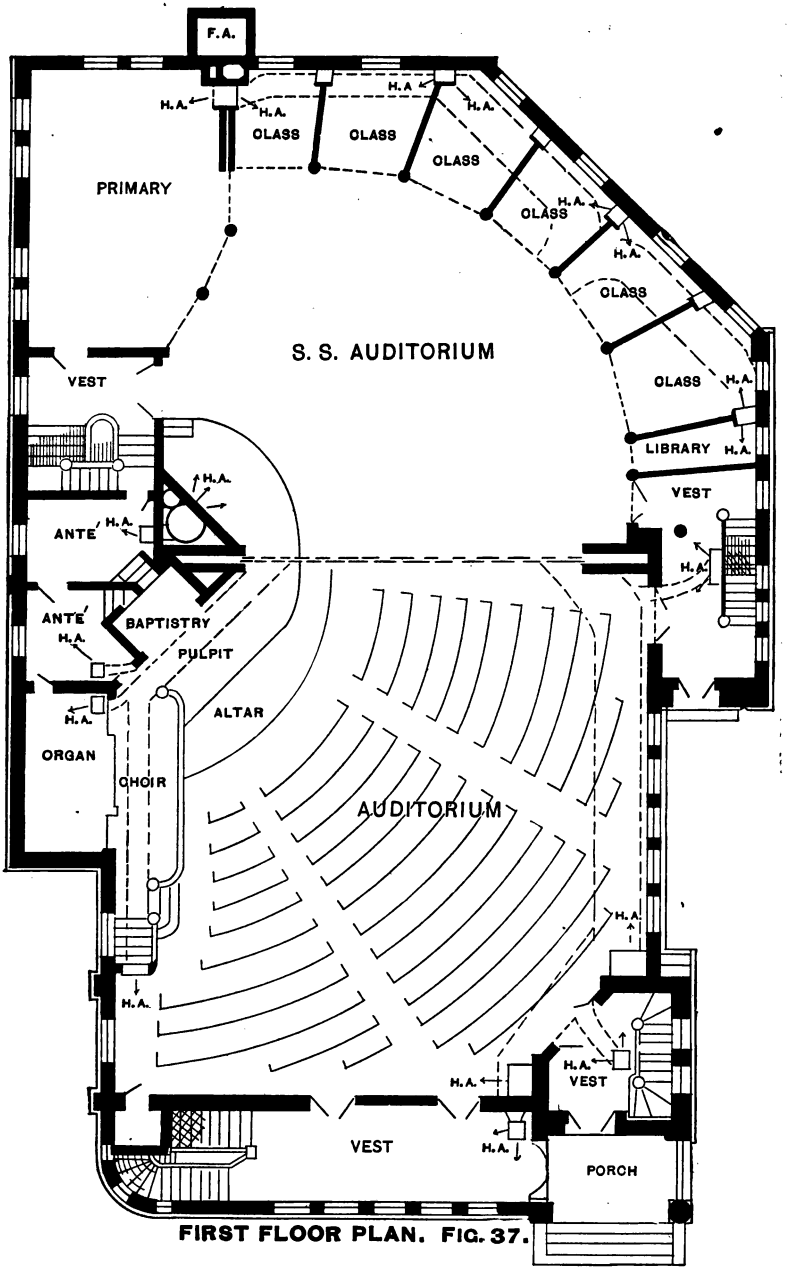

FIRST FLOOR PLAN. FIG. 37.

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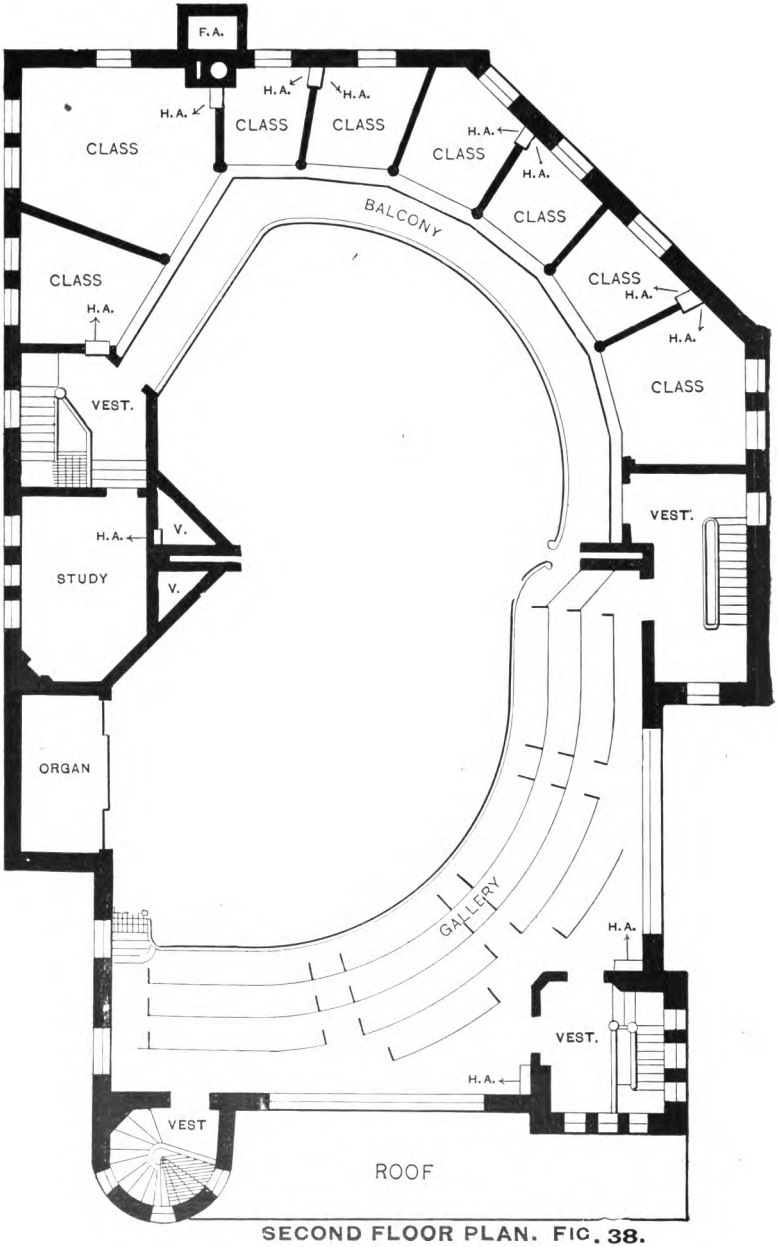

SECOND FLOOR PLAN. FIG. 38.

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Finally, after selecting the furnace I deemed best adapted, I arranged for installation with the maker, who, after investigation, endorsed the theories involved and entered with interest into the experiment, but doubted the capacity of less than four of his furnaces to comply with all of the conditions, which were to heat a volume of air equal to the contents of the building in 15 minutes, or 1,000,000 cubic feet per hour 70 degrees F.

Having room for but three furnaces of the kind selected, we were obliged to assume the chances. The furnaces were very carefully installed and connected, all ducts were placed, the fan and electric motor for operating the fan properly provided, and all prepared for the final test.

We were unfortunate in not being able to secure current to operate the motor prior to the day of dedication. Consequently the first practical test of the apparatus was made in actual service with a house crowded with people and the thermometer ten degrees below zero. The building was new and as usual, very cold. The electric current could not be obtained before 7 A. M. and services in the Sabbath School departments were to commence at 9 A. M. Meantime good fires were built and the furnaces in excellent condition when the fan was put in motion. We first concentrated all the air into the Sunday-school room, running the fan at one-third full speed; at 9 A. M. the speed of fan was doubled and a large proportion of the air turned into the main auditorium, the temperature in the Sunday-school department being about 65 degrees. Brisk fires were maintained until 11 A. M., when the connecting doors were opened, both auditoriums combined, and the entire house filled with 1,500 people. The fan was then placed at full speed and a uniform temperature of 65 degrees indicated.

The effect of the animal heat resultant from this large assemblage was soon apparent. The temperature continued to rise, the mixing dampers were gradually changed until it was found necessary in order to maintain a pleasant atmosphere, to mix fully two-thirds pure cold air with the warm air from the furnaces. No fuel was added to the fires after 11 o'clock until the close of the service, after a session of over two hours. The distribution, supply, and temperature of the air was perfect, and the atmosphere of the room was as pleasant after the service as could be asked.

Thus, the initial experiment was a success and was probably the most severe test this apparatus will ever be put to. The combination of a new house and exceptionally low temperature being a rare occurrence, with the first test also the first day of occupation.

This apparatus has now been in successful operation for several

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seasons, with no material changes, two furnaces doing the work under all ordinary conditions, only using the three in severe weather, while in spring and fall one proves sufficient; in this lies the great source of economy. The fan is operated at all times, summer as well as winter; supplying the regular amount of fresh air at the normal temperature or warmed as necessary. There is no complicated apparatus requiring attention or skill, more than the ordinary hot air furnace and the turning on of the electric current at the motor, with a little attention to the mixing dampers. A by-pass is provided so that the air in any principal duct can be changed instantly from hot to cold or tempered, still maintaining the continuous volume. This church was, to the best of my knowledge, the first one ever warmed and ventilated by the use of the fan and furnace in combination with furnaces in battery.

Many architects, engineers and committees have examined and investigated the operation of this plant, and in many cases have introduced similar ones, the advantages of the system for the colder latitudes being quite apparent.

Since the initial experiment, I have, whenever I found it advisable, introduced similar systems, using various furnaces, fans, and motors, and in no case has the system failed to give satisfaction. Others, drawing encouragement from my experience and the results, have introduced similar plants in other work than mine after advisory consultation, and in no case have I learned of a single failure, which certainly speaks well for the first introduction of a new system in the face of critical opposition.

Now as to conclusions. I am confident that while there are no new laws or principles involved, or new properties of matter discovered, there are properties not properly considered which enter into the problem and which must be recognized.

Heat must be considered from a scientific standpoint and is in many ways similar to electricity and light, in that many of the governing laws are common; for instance: The intensity of heat indicated as temperature corresponds to the voltage of the electric current. Thus we have a high voltage in the combustion chamber or generator of say 3,000 degrees; this we wish to convey to the several apartments of the building to be heated at a low temperature or voltage, say, 100 degrees. The quantity of heat generated depends on the amount of fuel consumed and rapidity and thoroughness of combustion, the result we call units of heat for lack of a better term corresponding to amperes of electricity.

This heat must be conducted from the combustion chamber in some way and imparted to the air; hence, we must deal with the

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conductivity of metal. Another coincidence is here apparent in the fact that the conducting values of the metals for heat and electricity are almost identical.

Heat is absorbed by that portion of the metal in contact with the fire and diffused to the air that is brought in contact with the exterior surface. Radiant heat is that portion or quality thrown off at right lines and is not taken up by the air, hence we have two qualities of heat to deal with. Radiant heat and air can both occupy the same space at the same time without either affecting the other, apparently. Is this the fact? I use the word apparently advisedly.

Air takes up the one quality of heat by coming in direct contact with the metal, thus becoming a vehicle for the conveyance current at the motor, with a little attention to the mixing dampers. rises; hence, to secure the best results the heat should be taken from the metal as rapidly as generated and absorbed, not allowing the temperature to rise by accumulation. For this purpose the air should be subdivided or cut up, so as to bring as many particles in contact with the heated surface as possible, as air only absorbs by actual contact and does not conduct within itself. It should pass at such velocity as to absorb in its passage only sufficient units of heat. The conductivity of metal decreases as its temperature of heat to secure the desired temperature.

Query.—What is the economic velocity of air over the heated surface of a furnace? And over what amount of metal should air pass at this velocity to absorb a given number of units of heat? At what velocity can heat be conducted through metal?

As ordinarily constructed the inner or absorbent surface and the outer or diffusing surface of the warm air furnace are practically equal, and the air passes in an unbroken sheet. The desired results can never be obtained with such apparatus. The heat generated will either consume itself so to speak or pass off through the chimney. I have experimental knowledge that the exterior surface of the furnace can be extended with good practical results to a development of from four to five times, thoroughly slicing and subdividing the air. This will, however, take off the heat more rapidly than it is absorbed, hence we must also provide absorbent plates to equal the diffusion. By actual experiment I have ascertained that heat can be extracted more rapidly than generated, with results fatal to combustion.

The proper proportioning of parts, volume and velocity of air, as well as the amount of extended surface, are all matters of engineering based on experiment. In extended surfaces continuity of metal is imperative.

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We have, however, lost the radiant heat. To utilize this, surround your furnace with absorption plates placed just a sufficient distance away to permit the passage of the necessary volume of air. The material and surface should be such that the powers of absorption and diffusion should practically equal each other. These plates should absorb all of the radiant heat emitted by the furnace, imparting it to the air (which should pass on both sides of the plates) by diffusion; thus by changing the quality or character of this heat, forming a secondary furnace, or what, in electricity, could be called an induced or secondary current.

By this it will be seen that the same results can be secured with the warm air furnace that are with steam—of increasing its capacity by the application of the fan. Thus, one furnace properly constructed and operated may be made to do the work of two. To accomplish this, however, as in the analogous case, means increased work on the part of the apparatus; hence much heavier furnaces are necessary.

To accomplish all this a furnace must be constructed on entirely different lines from those in the market, none of which are properly adapted for use with the fan to secure the best results, although I have secured very satisfactory results with some of the best. I am confident that with a proper apparatus greatly increased results might have been obtained.

Most of the furnaces in the market are constructed on some application of the same principles, generally copies of some predecessor, faults and all.

But little improvement has been made in warm air furnaces since steam and hot water have been introduced. All energy and ingenuity seems to have been spent in their evolution and improvement, the furnace meantime being side-tracked.

These conclusions are based on experimental facts. Many new phrases of natural laws not here referred to have been met, that are scarcely considered in practice, but which are vital to success. There are two schools, one of speculation and one of experiment and observation. In investigating nature and natural laws we cannot safely transcend experience, still we must utilize objects beyond the pale of experience. This borders on speculation, hence they are inter-dependent and neither can or should be ignored.

Many factors enter into the various complex problems, not herein considered, which are essential to success, such as proper fuels and methods of securing more perfect combustion, the conservation of every unit of heat developed, the principles of mechanical propulsion of air, the proper proportioning of ducts, velocities of

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air and best methods and location of ventiducts. So many features or subdivisons of the subject suggest themselves that their mere enumeration would make an article and their proper consideration a tome.

DISCUSSION.

Mr. H. B. Prather:—This subject is one of primary importance to all of us and, as a new field, is attractive, and the cheapness of the required machinery further brings it into prominence. I have made somewhat of a study of these applications and think that great improvement or change from present types, at least in the form of furnace, is necessary in order to secure economical and effective results. No doubt plants of this nature can be installed with success as far as the simple heating and ventilating is concerned, even with present types, as in the plant described, but the economy in fuel consumption and efficiency in heat development and utilization is the vital question and certainly is the question in comparisons with indirect steam or hot water fan systems. Mr. Kramer touches the important point in the statement that, "by actual experience I have ascertained that heat can be extracted more rapidly than generated." There is no doubt but that the absorption by the air of the generated heat direct from the furnace heating surface, and without the intervention of another medium such as steam or hot water, would naturally seem to be the ideal arrangement, but can such be done with any existing form of furnace heating surface and at the same time obtain proper combustion, or good combustion, of fuel i. e., proper generation of heat? I think not. The great efficiency of indirect steam heating with fans comes undoubtedly from the bringing of cold air with great rapidity into such intimate contact with the heating surface, as is done in the 1-inch pipe coils usually used with fan heaters, and the corresponding rapid conveyance of the absorbed heat by the air to the spaces to be heated, the air velocities of air passing over the surface in such heaters varying from 1,000 to 4,000 feet per minute and over. The rapid absorption of the heat by the air in such steam heaters does not in any way affect deleteriously or retard the generation of the heat in the boiler, but if we bring the air to be heated as rapidly, or nearly as rapidly, in direct contact with the heat generating source, as in a fan-furnace application, do we not seriously affect the combustion of our fuel, i. e., the heat generated? Certainly such action in the case of a boiler would seriously impair the combustion. In other words, is it not entirely possible that the combination of generating furnace with the absorbent agent, water, and

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the transmitting agent, steam, and the necessary adjuncts of steam pipes and steam heating coils, while it does involve more agents and less direct action, is the most efficient and economical heating arrangement? With retarded and improper combustion in the furnace we get uneconomical and incomplete use and therefore waste of fuel. Why is it that with natural gravity systems of furnace heating and ventilating in schools and churches the consumption of fuel is nearly 50 per cent greater than that of natural gravity indirect steam heating plants in similar buildings, and sometimes in excess thereof? An important factor in causing this is undoubtedly the poor combustion of fuel in the furnace. Certainly the use of a furnace of a form analogous, in principle at least, to that of the fan-heater with greatly extended and subdivided surface, bringing the air to be heated in intimate contact with a maximum amount of heating surface, will increase the efficiency of fan-furnace heating combinations, if some advantageous arrangement of heating surface can be used without serious detriment to the heat generation, i. e., the combustion of fuel. This is a serious question and its successful solution with only natural draft in the generating chamber of the furnace is doubtful; possibly the use of artificial or mechanical draft for the assistance of combustion may help overcome the trouble, but this would necessitate draft regulation and complicate the apparatus.

The claim of an advantage in simplicity of details of apparatus, and hence the requirement of much less attention and skilled handling, is not a very well substantiated one. The modern well proportioned steam plant with fan application for buildings of the size for which it is claimed this fan-furnace combination is especially available, with a gravity arrangement for return of condensation to boiler, and with a low pressure (10 to 20 pounds) slow speed (100 to 150 revolutions per minute) automatically governed steam engine running in oil, or a slow speed electric motor, arranged compactly and with automatic thermostatic regulation of air mixing, requires very little more attention or skilled handling, if any, than a fan-furnace combination plant. How about the heating of pastor's study, committee rooms, library, and toilets in churches when the remainder of the building is not in use? Would the furnace be run without the fan for them? Certainly the proportioning of air conduits proper for the best results with fan would not be proper when fan is not in use. In a steam plant direct radiation can be placed in these rooms, and a low fire in the boiler will raise sufficient steam for their use. Then, again, there will be always the serious danger of escaping gases through cracks and

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crevices in the furnace shell into the air to be breathed by the people; no such danger arises in a steam fan plant. Such cracks and crevices will be all the more liable to be had with a fan-furnace than with an ordinary gravity furnace, by reason of the greater differences in temperatures and incidental expansions and contractions. Any escaping gases would be rapidly conveyed to the unsuspecting lungs of the breathers of the contaminated air. There is no argument on the "price question," especially as to first cost. The fan-furnace combination would only be a little more expensive than the simple furnace plant, and would be considerably cheaper than a steam fan heating and ventilating plant, with hot and tempered air ducts, automatic regulation, etc. We are all anxious to see forward strides made in the science of heating and ventilating, but it is well to carefully consider results and "weigh them up" critically. A truly successful plant or apparatus must not only simply do its proposed work, but it must do it with the maximum efficiency and economy in heat generation and utilization, with the least possibility of the arising of unpleasant conditions and breakdowns, and with a minimum size of apparatus to do all this with ease.

Mr. Blackmore:—I would like to ask Mr. Kramer a question or two. I notice in the drawing here given that the air is forced over the furnaces by the fan. I would ask whether the author has ever tried placing the fan on the other side of the furnace and sucking the air, as it were, through the furnace, and if he has made those experiments whether he found any difference in the results and what the extent of the difference was.

Mr. Kramer:—I will explain as briefly as possible. We have tried the fan on both sides of the furnace and the first application of the fan as an exhaust on the furnace raised objections that to my mind were so reasonable that I never gave it second consideration. There is no furnace constructed that will remain air tight after continued use, and to exhaust over the furnace will certainly produce the results Mr. Prather has feared—to exhaust the gases of combustion from the furnace. The proper plan is to maintain the furnace in a plenum chamber. Every crevice in the furnace would then offer the shortest circuit for the air, which would find its way to the flue and act as a check draft on the fire. I have taken a hammer and in a furnace have knocked a hole that you could stick your fist through, put the fan in operation and not a particle of gas or smoke escaped. The result was to check the fire. If the hole is close to the fire it will act as a blast and assist combustion, but if it is back of the fire it will act as a check draft. The

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location of a fan never should be considered but on one side of a furnace.

Mr. Payne:—I would like to ask if Mr. Kramer has used both extended and plain surface furnaces and if he has noticed any relative difference between them.

Mr. Kramer:—The furnaces that I used in this one case had extended surfaces probably 50 per cent in excess of plain surface. I have used the ordinary furnaces without any extended surface. In one instance in Connecticut I had a church in which there were placed originally two of the Smith & Anthony largest furnaces. You probably all know what that furnace is. It is a round drum furnace. They originally placed two of these furnaces without any material change in the construction. After some experiment there were substitutions made in the way of adding extended plates or extensions. The extensions, however, were not continuous metal, but were applied afterwards. They did not prove satisfactory. It was necessary to add another furnace to the plant to get desired results. In another church near by they made an improvement in their furnace and added continuous extension plates to their drum with greatly increased results. I have a plant not yet in practical operation in which the plates of the drum are of cast iron studded with pins. I cannot say what the result of that will be, but I know it will far exceed the plain surface. The furnace referred to in my paper had 3-inch vertical extension ribs placed three inches apart. There were no corresponding plates on the inside of the furnace. Consequently the furnace could absorb no more heat than the inner plain surfaces of the exterior plates, while greatly increasing the radiating surfaces. By experiment on another furnace we extended those exterior plates from three to six inches. With all the tests we could make those plates were heated to the farthest limit practically the same amount they were when three inches. We afterwards tried the experiment of adding inside absorbent plates, endeavoring to absorb a corresponding amount of heat and using the continuous interior and exterior plates as conductors. We experimented quite a while on that, but finding it difficult to maintain the combustion we gave it up for the time. We have within two or three days received a communication from a party who has been continuing these experiments, stating that he has succeeded in securing very good results with 12-inch extension plates, both exterior and interior. He does not think it policy to extend them further and he finds that the capacity of his furnace is fully doubled. That does not mean that you can utilize double the units of heat from the same combustion. You must maintain more fire and gen-

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erate more units of heat, the furnace doing double the work. On the same principle that the capacity of a steam radiator in the form of a coil, by passing the air over it very rapidly can be greatly increased, whereby (as some authorities claim), you can increase its heating powers from five to six times, as in the forced blast system, we find that we can increase the capacity of a furnace; but to what extent we do not know. We are only experimenting at present; we have no definite data.

Mr. B. H. Carpenter:—As to the question of economy in running in that way, it is a question of economy in installation of the plant to put in one heater in place of three, but would it be in coal consumption? Mr. Prather brought up the question of economy of steam over furnaces. Have you had a practical test of that?

Mr. Kramer:—I have not made any tests more than I would compare one building with another. If it is properly introduced and intelligently operated, I cannot see that there is any more imperfect combustion than with a boiler. The combustion chamber must be protected.. It will not do to chill it in a stream of cold air, any more than to put the bottom of a furnace in a stream of cold water and expect to maintain heat. You must apply some common sense to it, as well as some scientific knowledge. I cannot see but that we get the result from the heat generated in that furnace as nearly perfect as we do with steam. It always seemed to me, when experimenting in maintaining a fire in a furnace and generating a certain number of units of heat, that the quicker we conduct that to the air and convey it to the apartments to be heated the better it is. I think it should be imparted to the air at once. If a sufficient number of intervening mediums are introduced they will absorb and lose all the heat, and if that will hold good in an extreme case, it will hold good with one or two mediums to a corresponding degree.

Mr. Mackay:—I would like to ask if the projecting points are the best points for applying the heat to the air, or if better results would be obtained by corrugations, which would perhaps double the amount of surface in the body of the furnace?

Mr. Kramer:—On that point I have not made up my mind. I am not positive. I fear the corrugations occurring on interior also, if deep, would embarrass the combustion of coal. There would be chilled chambers in those corrugations in which the heated gases would not penetrate. That is the trouble we had with the 3-inch plates on the inside. The spaces between the absorbent plates forming cells, as you might call them, would fill with stagnant air or gases, thus insulating the air to be heated from the heated cham-

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ber. We found the difficulty was that the smoke and unconsumed gases settled in those chambers and it was impossible to move them. In fact, the fires went out; we could not maintain the fires in the furnace, and we only made one attempt at it and broke up the furnace because improperly introduced.

Mr. Connolly:—In regard to Mr. Kramer's remarks to Mr. Blackmore about forcing or sucking the air through, he said he took a hammer and drove a hole through the furnace. I would like to ask whether the furnace was cast or wrought iron and into what part of it he drove the hole before experimenting with a fan.

Mr. Kramer:—I would say that the furnace I experimented with was what is known as the long low, a cast furnace of the Smead pattern. There was an oblong grate, probably three or four feet long, and the furnace was probably 10 or 12 feet long. The first furnace I experimented with had a corrugated exterior surface, and we broke the hole probably half way between the rear extension and the grate at the upper portion of the furnace, where there would be more likely to be heated air and pressure from the gases to come out.

Mr. Quay:—I would like to ask Mr. Kramer to what temperature the outside of the furnace over which the air passes is heated, and what the temperature the air is after passing over the furnace.

Mr. Kramer:—I can only answer that in this way, that we never succeeded in heating the furnace red hot; consequently it was at a temperature below any possible change in color. I never made any instrumental test as to that. I have always endeavored to maintain the air as it enters a room at about 100 degrees. While we have not been experimenting in a scientific way upon that point to ascertain data, I have maintained the motion of the fan at such velocity that the air could not heat beyond that temperature. We have moved the air at a velocity of from 1,500 to 2,000 feet fan delivery. Of course the chamber in which the furnace is located has more area than the area of the fan. Consequently there is a reduction of speed in passing over the furnace.

Mr. Blackmore:—In looking over the question as to whether inside or outside of the furnace chamber is the best position for the fan, it occurs to me, if what Mr. Kramer says is correct, that if the furnace is ample in size, the air supply also ample, and the fan chamber between the furnace and the fan of sufficient capacity, the flow of the air over the furnace will not be great enough to draw gas from the furnace. I would be inclined to think that the conditions would be provided for, so that the draft through the furnace, as it were, would be a great deal less than up the chimney. Of course in the

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case of a check draft or a poor chimney I can imagine there would be danger. But as a general thing I think that the size of the chamber could be made sufficiently large, so that the velocity of the air passing over the fan would be great enough to prevent any gas escaping into the air chamber. I may be mistaken about this, and that is the reason I asked the question in the form that I did. I would ask the members if they ever tried anything of the kind or not.

Mr. Wolfe:—While I should not care to tell the gentlemen about some of our mistakes, there have been some experiments made in the furnace end of it, and regarding the fan part of it we arrived at the conclusion that the fan preferably should feed the furnace chamber rather than exhaust from it, for the reason that we allow about 20 per cent. for expansion in warming the air. Consequently if we provide by power an amount of air that shall equal the flue capacity we have added to the inward pressure in the furnace chamber about 20 per cent that is given by expansion, and consequently the possibility of the gases escaping into the chamber and to the rooms is avoided, whereas in the other case we found that we got gas, that is all.

Mr. Kramer:—I think I can cite one instance where the experiment was made. I cannot refer to the location, but there are some parties who introduced some furnaces in an asylum. They came to me to look over their plans and spent several days consulting over the matter, but they were determined to have their own way about placing the fan. I tried to convince them that the proper place for the fan was to force the air and not to pull it. They were quite confident that they were right and placed the fan in that way. I received letters from them afterwards stating that they had spent I don't know how much money trying to make those furnaces air tight, so that gas would not get out, and finaly they had o rebuild the whole plant and put the fan on the opposite side and now it is a success.

Mr. Carpenter:—I would like to ask if there is any preference in putting the furnaces all in one nest instead of distributing them around in different places.

Mr. Kramer:—If the plant is to be used entirely as a blast plant it is more economical to concentrate everything in one locality and make the calculations the same as introducing a steam blast apparatus. But if you intend to use any part of it (without using the fan) as a gravity apparatus, it is best to locate the furnaces to be used for that purpose in proximity and below the apartments to be heated; then you can use the furnaces to some extent without

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using the fan for heating some subordinate rooms by gravity. But I have found that the sacrifice of apartments in distribution of apparatus is sufficient to overcome all that objection. In several cases, for small apartments, when the plant is not in operation, we find that it is more economical to place a gas heater in those rooms and warm them by this means. If necessary, a secondary furnace can be located somewhere for that purpose. I think it is more economical to concentrate your apparatus as a power apparatus and only use it for the entire or larger portion of the building. It is not economy to use an apparatus intended to heat a house of two or three hundred thousand feet capacity in order to heat two or three small rooms.

Mr. H. J. Barron:—When a saint is to be canonized there is always a devil's advocate. In this particular instance I want to be the devil's advocate. Mr. Kramer says in his very valuable paper: "But little improvement has been made in warm air furnaces since steam and hot water have been introduced. All energy and ingenuity seems to have been spent in their evolution and improvement, the furnace meantime being side-tracked." There is a beautiful law of nature which Mr. Kramer, if he is an evolutionist, thoroughly understands, which explains why he has been side-tracked. That is that everything as it advances tends to complexity. Man himself, in developing from an inferior type, became more complex. Every art gets more complex as it advances, and when hot water and steam were applied, that knocked out the furnace and it has been practically dead since.

Now there are several admissions which Mr. Kramer has made. I think the beauty of his paper consists in the honesty of his admissions. If you knock a hole through and you have a plenum it is all right, but if you do not have a plenum the gas goes up into the rooms and the people are killed perhaps. The fact of the matter is that with a furnace as ordinarily constructed, or I do not care if it is constructed in the best possible manner, it is impossible to make a thorough, satisfactory job of heating and ventilating. The only object in all this is cheapness of first cost. You get at the cheapness of first cost by dearness of the ultimate cost. If you take any number of years through which you run a plant of this sort, probably the repairs would cost a great deal more than a steam plant would cost in the first instance. There have been experiences in this country and in England. For instance, there is a gentleman in this city who for the last ten years has heated his own office building down town with fans and furnaces. But it is the only building down town that is heated that way. He used his ingenuity

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and his energy in trying to push this arrangement. It has failed. It has not failed through not having capital enough, for this gentleman is a millionaire. I have not heard that the Englishmen who have been trying the same plan have had better success. Mr. Kramer further states in his paper that he could not get any one engaged in the heating and ventilating business to go into this manner of heating. The simple reason for that is that it would not be profitable. The thing is a failure from the start. The greatest genius that ever lived, if he applied himself to make this thing a success, would utterly fail, because it goes contrary to natural law; it goes contrary to the experience of mankind.

Mr. Wilson:—I understand my friend Mr. Barron to state that there has never been a complete job of heating and ventilating work done by a furnace. I would respectfully refer him to some reports of Inspector Wade of Massachusetts. The people down there are supposed to be very bright, and I think they are almost too astute to make a report, year after year, and give data showing that the system has given satisfactory service, unless it was so. I must confess I am a little surprised, knowing Mr. Barron as well as I do, that he should make such an assertion. He might stand here all day and say that that system would not work, but you must recollect that the paper presented by Mr. Kramer is a consummation of practical facts, and we have no reason to doubt any assertions that he makes in that paper. It is a practical illustration of a practical working plant at the present time, and I think that in arguing this matter we should argue it from that standpoint.

Mr. Blackmore:—I admire the "devil's advocate" very much. I think those advocates are very useful; they set us thinking. If it was not for the devil's advocate we would not have a quarter of the theology that we have now. It is a well known fact that our apparatus of all kinds is getting more complicated. It is also a well known fact that the best minds in electrical science to-day are devoting their attention to the discovery of means of getting the electricity directly from the fuel without any intermediary apparatus. Until an electrical system of heating is perfected the hot air furnace is the ideal method of heating if we could only get the proper application of it. It takes the heat directly from the coal to the air. In so far as that, I quite agree with Mr. Kramer. The only thing is for us to get the proper form of furnace, so that we can economically absorb the heat as it is generated. There is only a certain number of heat units in a ton of coal, and in the utilization of them there are two things to consider; first, we must

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get perfect combustion; therefore we cannot complicate the furnace by corrugating too much. If we could get a furnace with its surfaces properly proportioned, so that the heat could be transmitted through the iron and then absorbed by the air as rapidly as possible, we should have an ideal system. The furnace has not been abandoned because it was not practicable, but because the various forms in which it has been made have not proved sufficient to effect an economical transmission of the heat. Whether it can be made sufficient to accomplish that purpose or not is another question. But the fact that it would be the most economical, if we could get the proper form of furnace, I think is beyond question. It makes a very much more simple apparatus and certainly a more economical one if we did not lose so much heat up the chimney. If by utilizing the fan you can deliver the air in such quantities that you can absorb all the heat from the furnace as rapidly as it is produced, I claim that you have a more economical apparatus than you can possibly get with a stream of water.

Mr. Wolfe:—If I can resurrect myself—I suppose I am one of the dead furnace men—I would like to say that I think, if the furnace is abandoned, and if you try to collect any salvage in Massachusetts, you will not get it. The furnace is quite a factor in the East in relation to ventilating public buildings. There, you all probably know, we are governed by certain standards. We are not governed at all as to heating by law, but we have to guarantee to warm the building. There must be an air supply of 30 cubic feet per minute per capita and it must be so distributed as to keep it at a certain degree of purity; about .0006 is the limit. I do not believe that a perfect furnace is made to-day, any more than I believe that the most perfect system of boilers is yet made by any manner of means. But I can give you a few figures that are actual facts. We did not make them up for our catalogue or anything like that. We simply took them from the reports of one city in Massachusetts. There are in that city 16,000 and odd hundred school children according to their school reports. The fuel expenditure for one year in that city was 25,000 and odd hundred dollars, making the average cost of warming and ventilation $1.57 per capita, all acting on the same standard by law, because if the people who did that work did not comply with the law they would not have obtained their money. Every one of those buildings had been tested and accepted and found to comply with the law, and the average cost was $1.57 per capita for warming and ventilation. The best job in that city that was done by steam was $1.18 per capita and the best job that was done by furnace was 91 cents per

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capita. Now this is in the city of Worcester and the figures I have given are on the books in the report for 1894.

A Member:—I would like to ask if there is any data on the cost of repairs to the hot air furnaces and steam systems used for the same purpose?

Mr. Wolfe:—I do not know much about steam. I do not know much about the business of anybody else. But I know that in eight years we have equipped in the city of Worcester eight buildings, and in eight years we have sold them less than $15 worth of repairs. That would not pay for cleaning out one boiler in the summer.

Mr. Cary:—It might be interesting to know the buildings in which these different systems of heating are used. I have known two buildings, approximately the same size, heated by steam apparatus in which the cost was very different. It would figure down to a cost per capita very different in some buildings a great deal more exposed than others, and I would like to know what proportion of the buildings this gentleman has spoken of are heated by furnaces and what proportion by steam or hot water. I think the character of the building would have a great deal to do with the ultimate figures.

Mr. Wolfe:—I think that question is very reasonable and possibly I can give a reasonable answer to it. The schools, of course, are taken as they are shown in the report. There are many more schools heated with steam than with furnaces. The comparison was drawn from the very best results obtained by steam among all the buildings they had and the best results obtained by furnaces. I know the building that those results were obtained in. It is a 12-room building and every room is a corner room. That is, it has two exposures. The building is two stories high, and that is a pretty severe test. It stands in as exposed a position as there is in the city of Worcester. If you know the town—I think it is out near Clark's College, opposite the University, with no immediate surroundings or buildings or anything to break the wind. The best steam heated building, as I understood, was down in the city proper. I am not prepared to say that it is not just as exposed as the other. I am simply speaking from the school report and the report of the superintendent of buildings, choosing the best in each case.

Mr. Wilkinson:—I would like to state one or two facts that came to my knowledge lately. Two, possibly three residences, the finest and largest erected in the city of New York by millionaires of this city, within the last three years are warmed entirely by hot

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air furnace plants in preference to steam or hot water and at a much higher price. The reason given for this was the fact that one of these gentlemen stated that steam heating and hot water heating had, in his opinion, been relegated to the rear and that hot air was to come to the front, from the fact that he had experimented with both in a great number of buildings in New York city for residence purposes and had come to the conclusion that hot air was the best and most practical and that he would not live in a house unless it was warmed with hot air. If the names were mentioned here they would be known to everybody as carrying a great deal of weight and influence.

I simply want further to state that while a large portion of my business has been hot air heating lately I have in the past year done a great deal of steam and hot water heating, and I have come to the conclusion that the majority of residences such as we reach in this vicinity and neighborhood, within a radius of a hundred miles of the city, are being warmed with hot air and that the only reason why hot air and hot air furnaces have been side-tracked is simply because of the inefficient method of installing the plants. I had a case that came to me a little while ago where a gentleman who is building a fine residence in a suburban district in New Jersey brought me three plans for warming his house and he wished me to make an estimate for steam, for hot water, and for hot air. I first inquired what amount he intended to pay for the installation of the plant and he said he had a price for heating by steam at a certain figure and he did not wish to exceed it. I made him three several estimates. I said to him, "if you wish me to install a hot air plant I can do it and do it successfully, but it will cost you more money than to put in a steam plant, and he finally gave me the order for the hot air. I merely speak of these things because to a certain extent hot air heating is coming back into use because of the fact that it is possible to heat by hot air and give good results. I think the time is coming when a combination of these different systems will probably prove to be the most successful, especially for residences.

I wish simply to make the statement in regard to this paper of Mr. Kramer's that I have heard from several of these plants that have been installed under his process and I have heard only the best results from them. I myself installed a plant in a church from this same plan, not using the fan however, but using a combination system, and I heard from the committee using the same identical plan in another city with this fan system saying that the work was most successful in every way and was giving the best

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results. I merely speak of this to champion the cause of hot air heating.

Mr. Quay:—I want to call attention to one statement made by the last speaker—that the reason furnace heating is in the background is because the systems are not properly installed. That is no more the case than it is with steam and hot water. The reason that people are able to make a price on heating a house with steam or hot water cheaper than with a furnace does not need any explanation in regard to what kind of a heating job they are going to give. Hot air furnace jobs can be properly installed as well as steam or hot water jobs, and it is not only the effectiveness of the job but the economy of operation that is to be considered. You put in a poor job of heating with steam or hot water and it will not work properly and it will not be economical. I do not think I better discuss this question any more on this paper, as it is probably a little out of order, but I merely wanted to advocate the other side a little.

Mr. Cary:—The remarks this gentleman has just made are somewhat in the line about which I felt like saying something. With the smaller sizes of boilers used for plants I am not so well acquainted as I am with the larger boilers used for office buildings and larger plants. They say a little knowledge is a dangerous thing, so I may be walking on treacherous ground in speaking as I do. I do not know as much about hot water heating as I do about steam heating, but for smaller plants I have seen some very curious combinations of metals that are called boilers. There is no economy in them. The requirement I believe of the boiler inspection bureau of the New York Police Department is that boilers above a certain pressure must be operated by licensed engineers. I think that runs somewhere about ten pounds. There are very few steam heating jobs that are operated above that. In consequence they can take up any Tom, Dick, or Harry around town and put him in charge of the the plant. He will clean the boilers or not as he pleases. Very soon boilers become foul, and I have seen a good many plants where they are not fit to run. They would not be operated in that way in a larger plant where they have a licensed engineer or a man who understood his business. So this comparison between the efficiency of steam heating, reckoning right back to the fuel, and the efficiency of hot air heating, is hardly a proper comparison. But I suppose that steam men will have to take it that way, although the boiler is very much handicapped. It is hardly a fair comparison.

Mr. Wolfe:—We have all been at this thing long enough to know

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that a house on one side of the street and a house on the other side of the street equipped with the same apparatus will show different results. I have not had anything to do with a house heating job, I think, in ten years, with one exception. All that I have had to do has been in buildings where we were working under a guarantee such as is required under the Massachusetts law or when the committee would say, "We want so much air." I quoted Worcester and the schools of Worcester simply for the reason that I thought that could be judged upon a common plane; that is, that we were all giving the amount of air and necessarily giving the amount of heat to warm the air and obtaining the same results that were judged by disinterested parties and reported by disinterested parties. That is the only reason why I quoted Worcester. But the question of fuel in one house as against another, I do not think cuts very much "congealed water." But take a public building where they are bound to give certain results and practically the same warming, you then can get at pretty nearly a fair comparison.

Mr. Wolfe:—I do not think that any hot air furnace crank—I suppose I am one of them—would go to the extent of saying that he could heat every house with a warm air furnace or that a warm air furnace is best for every house. There are lots of houses in which, if a man is honest, he will tell people to use either indirect steam or indirect hot water. But there are places where furnaces are being used and the results are eminently satisfactory.

Mr. Mackay:—While I do not wish to run down the hot air furnace and believe that it is best in a great many places, I do not think that any endorsement of the hot air furnace by the millionaires of New York, who perhaps had poor experience with some steam or hot water system, helps the hot air furnace or hurts the other systems. I have a case in mind where a plant was installed in the best possible manner, in an ordinary house building of a rather rambling description, up in Northern New York by one of the leading furnace concerns in the country. They did not come up to their agreement. The furnace was taken out. Another furnace concern who had estimated on it originally took up the matter. Their head man spent one week there in placing the furnace. It did not succeed as well as the first furnace. That was afterwards taken out and a hot water heating plant installed by a small concern up in that part of the state. This is a case of the heating of one building by two of the best furnace concerns in the United States and by a small hot water concern. The hot water plant has been in now some five or six years. The occupant of the house, who is not a mechanic and who knows nothing about steam or hot

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air or hot water, except that he heats by them, claims that he thoroughly heats the entire building during the winter and does not burn fifty per cent of the coal he burned with the two hot air furnaces, neither of which heated his entire building. That is one instance where hot air furnaces supplied by the best concerns, one claiming forty or fifty years experience and put in by their best man, did not make a success, while an ordinary hot water concern did make a success and made an economy of fuel.

The President:—Gentlemen, let me ask you to keep to the question which is "forced blast warming with furnaces."

Mr. Mackay:—I would not have mentioned the matter, only that the discussion drifted in that direction and I did not want to have any wrong impression go out from this society.

Mr. Blackmore:—The question of cost per capita in heating and ventilating schools is brought up, and from what a member said about it the impression was left on my mind that more economical and better work has been done by hot air. I am somewhat interested in school heating and ventilation, not so much practically, perhaps, as experimentally. For my own information I have collected a good deal of data as to the cost of heating schools. I find that it varies very much more than the cases and the apparatus would seem to warrant. In some towns I nave seen the schools get much better results from steam than from hot air; in other towns much better from hot air than steam. I have also investigated those steam plants that have given good results and those warm air plants that have given poor results, and I have found that there are two things that cut a very large figure in the cost of fuel; that is the care that the apparatus gets from the man who is in charge of it; the other is the care with which the apparatus is installed. The mere fact of saying that one building is more thoroughly heated than another is not a factor in the case. The question is, Is the system thoroughly put in and does it have proper care? Do they have equal exposure and are they required to do the same amount of work? I have known a lower ratio per capita than 91 cents, but such instances are very rare. I have seen furnaces where they were costing $2 per capita, not because the principle was wrong, but because the apparatus were not properly applied and in some cases not properly looked after. I do not see how it is possible to make a hot air furnace do better than a steam plant if properly installed. Therefore you must not go away with the idea that because one building or one class of furnace or one class of heating apparatus gives better results for one class of building per capita that it is the best system, but we must study

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the principles that underlie these things and ascertain whether they are applied properly and looked after properly.

Mr. Dean:—I desire to ask Mr. Kramer if, when the building is unoccupied, there would be any objection to taking the air from the room and circulating it over the furnaces until half an hour prior to the time for the people to assemble. This would be quite a reduction in the amount of coal consumed. Are there any objections to such a system?

Mr. Kramer:—I presume that the question refers to what is known as the revolution of air. I do not know that there would be any objection to the use of that. I do not know that there would be any complication arising from it. I have done this in connection with steam apparatus, but never in connection with fan and furnace. Before this discussion closes I would like to set myself right before this society in one respect. I have not come here as an advocate of a new system, or as an advocate of hot air furnaces, or anything of that kind. In my business the introduction of a heating apparatus is merely an incident, and if I find a building for which I think steam is best adapted, I put in steam, and if I find hot water the best I put in hot water. I have in this paper endeavored to show that for certain buildings which are occupied only a portion of the time this system is probably the best adapted. I have had communications within the last couple of weeks from an engineer in Montreal who has thoroughly investigated this matter and introduced this system in the school houses in Montreal, and I think his experience would be of some value. He reports to me that nearly all the schools in Montreal have adopted this system. There are some minor objections which could be overcome by more perfect installation possibly; but in presenting this paper to you I have not come here for the purpose of advocating this or any system; it was on the request of certain persons, to advise them regarding my experience on some new subject. I can give you a paper on steam heating and probably talk on steam heating also. I have more steam heating plants than furnace plants by scores, and if you will refer to Mr. Prather's paper, the second church he refers to is one that was installed and the entire plant laid out and indicated by me. The engineering was turned over, of course, to Mr. Prather. As regards steam heating plants, that is one of the most difficult pieces of engineering I have ever seen in the way of heating, and to secure certain specific results. I am watching it very closely as to the results.

Mr. Cary:—I merely wish to say that there have been a good many references to the price of heating per capita. We might put

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two people in a building or we might have a hundred, and I think that is rather a dangerous standard to go by, and it is very misleading. If the cubical contents of the building is compared with the number of people in the building, or the size of the heating plant, there may be some safety in making such comparisons, but otherwise I think there should be some definite ratio fixed so that we could get at a definite result.

Mr. Wolfe:—When I say per capita I will explain what I mean. The cubical contents of a building we simply figure as an incident, in Massachusetts, regarding the heating. What we have to work to is so much air and the warming of so much air and the circulation, and what we first want to know is how many people are to be in the room. In a school room there are from 48 to 60 desks, depending on the size of the room. In Boston the rooms are sized by law. The ordinary graded school is 28 by 30 by 12, with 50 desks and one teacher. When I said per capita, I probably should have said per seating capacity. When the estimate is made by the state inspector, he does not count noses but he counts chairs, and the ordinary school room has 50 scholars' chairs and one for the teacher, and if we do not put in 1530 feet of air we do not get our money.

Mr. Quay:—I think that possibly an explanation is necessary—that this discussion has not been intended as a cirticism of Mr. Kramer's paper. It is merely discussing the statements made by our members. His paper is all right.

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XIX.

THE COOLING OF CLOSED ROOMS.

BY H. EISERT, BALTIMORE, MD.

(Member of the Society.)

Before entering upon the subject of this paper proper I take the liberty to make a few introductory remarks, but I wish to be understood that these remarks are general and bear no allusion to any personality whatever.

It cannot be denied that there is still a strong tendency among the heating and ventilating engineers to discredit "theory." Well, theory and especially as applied to heating and ventilating problems, is, like a boomerang, dangerous to handle. However, that should be no reason why our modern engineers should shun these theories and depend solely on practical experience of their own, or sometimes others, since it is also an indisputable fact that many of our practical men, though they have very distinct opinions of their own, are greatly at variance on certain points and subjects. Of course every one of these practical men bases his opinion upon his own practical experience while exercising his skill with the intention to obtain results satisfactory to himself and any other party interested therein. Now, right here, we must contend that, if a certain case be put before several practical experts, who themselves work and plan entirely independent of each other, the results will invariably differ, according to the more or less peculiar ways of treating heating and ventilating problems which may have been developed or acquired in various individual offices or shops. This fact may be considered as one of the reasons why so many opinions or results in heating and ventilating matters are more or less one sided, or even shortsighted, while some, I am sorry to say, have neither side nor sight at all.

It is not only the knowledge of the practical "how to do it," which we justly expect from every first-class steam or pipe fitter, but it is the additional knowledge of the "why and wherefore" that makes the engineer, and that knowledge can be acquired only by a persistent study and analysis of practical results without prejudice and personal prepossession. But this, again, is utterly impossible

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without a thorough knowledge of the fundamental laws of heating and ventilating. All the laws which, at the present time, are usually applied to heating and ventilating problems, and which are too often disregarded by so many, were derived from practical experiments conducted either in the laboratory or else under common natural conditions by men like Pèclet, Dulong, Regnault, Pettenkofer, Grasshof and others of equal scientific fame, the name alone of each of which is a guarantee for the value of their conclusions. It is indeed very deplorable that more of our skillful engineers, though they are not few and far between, do not spend some of their time in this kind of work. Is it really lack of time? Of course, one might object to giving away the results of his labors for the benefit of others, but on the other side again, if every one of our members takes that ground, the chief object of this society would be little more than a myth.

Though the foregoing remarks have really no bearing on the following subject, I make them to serve as an excuse for the form in which the subject of this paper is presented to this society. My object is to give theoretically the basis of a scheme of which I found a short treatise in a well written and well commended book on heating and ventilating by Prof. H. Rietschel of the technical high school, Charlottenburg, Germany, which I assume to be of sufficient interest to the members of this society. I trust that our more practical engineers will give it the due consideration it deserves and a fair trial should the occasion arise.

In its principle the cooling of closed rooms is nothing else but a negative heating. The purpose of "heating" is to counteract the loss of heat; that of "cooling" to subdue any excess of heat. An excess of heat may be caused by the transmission of heat from the exterior to the interior through the walls of the room, by the direct generation of heat by the occupants, the illumination, or any other special cause.

The determination of the excess of heat is based on the highest outside temperature, the limits of which naturally vary with the geographical location and the prevailing meteorological conditions. In the Middle Atlantic States a summer temperature of 95 degrees F. in the shade is considered a mean maximum. The direct heat of the sun, which favors the conditions during the heating season, must be well considered in determining the excess of heat during the cool season. An allowance of from five degrees to ten degrees additional to the mean highest outside temperature of the locality will generally suffice for rooms exposed to the sun.

The quantity of heat generated by human beings varies with the

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age and physical conditions from 6.6 (99-t) to 13.2 (99-t) B. T. U. per hour, if t represents the temperature of the surrounding air.

The generation of heat by electric illumination varies with arc lights from 2.25 to 6.25 B. T. U. and with incandescent lights from 11.5 to 21.25 B. T. U. per candle power per hour, according to the character of the current. Illuminating gas generates an average of 600 B. T. U. per cubic foot.

There is another, and as such, a very important factor which must be considered in the cooling of closed rooms, and that is the humidity of the air. It is a distinct property of the air to expand when warmed and thereby to decrease its relative humidity and to contract with a corresponding increase of its relative humidity when cooled. If the air be cooled below the dew point, part of its moisture will be precipitated and the air, though saturated, will contain less moisture than before.

In rooms which are cooled by direct cooling surfaces it is always to be expected that the relative humidity of the air therein may be increased so much as to cause the precipitation of a corresponding quantity of moisture on the cooling surfaces and adjacent objects if a sufficient quantity of air is not introduced into the room to absorb the surplus of moisture.

Such increase of the humidity of the air in occupied rooms beyond a certain limit causes a disagreeable sensation to the occupants, especially in summer time, when the absolute humidity of the atmosphere is naturally high. Besides, the presence of direct cooling surfaces in the immediate vicinity of the occupants is very objectionable, and should be tolerated only in rooms for industrial purposes, as in fermenting rooms, cold storage rooms, and the like.

The better and more sanitary method of cooling occupied rooms in which a large number of people are liable to assemble will always be to introduce moderately cooled but correspondingly dry air into the rooms. As already stated, the relative humidity of the air increases with the decrease of its temperature; this property of the air is now made use of in such a way that a certain quantity of the air supply is first brought in contact with cooling surfaces of low temperature, so as to cause the precipitation of as much moisture as possible. This air is then mixed again with uncooled air in a proportion that depends on the relative humidity of the atmosphere. Sometimes it is even necessary to conduct this mixture over heating surfaces in order to avoid its entering into the rooms at too low a temperature.

By the cooling of a room in connection with its ventilation the condition of a moderate and agreeable degree of humidity can be

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obtained, inasmuch as a moderate excess of temperature is not so objectionable as a high humidity of the surrounding air. Under all conditions, however, it is advisable to fix the limit of the humidity of the air in the rooms to be cooled and to proportion the cooling apparatus correspondingly.

The running expense of a cooling apparatus is materially reduced by causing a repeated circulation of the air in the room over the cooling surfaces, without discharging any of the used air into the atmosphere when cooling the room before its occupation. Such reduction of the running expense is here of more importance than with the application of the return circulation of the air for heating purposes, because the cooling surfaces not only absorb the heat contained in the air, but also the latent heat of vaporization of the precipitated water which was absorbed when the water changed its state from the liquid to the vaporous, and now becomes sensible again.

At the highest temperature of the outside atmosphere the walls of a building are naturally of a higher temperature than that prevailing in the building. If, by some means, the walls of any one or more rooms be cooled, these walls will act as cooling surfaces. Such cooling of the walls can be accomplished only by means of cooled air which is introduced into the room before its occupation, as the air for that purpose naturally must be at a lower temperature than would be agreeable to the occupants. In many cases, however, it is necessary to assist the cooling apparatus in this way by introducing cooled air into the rooms for a reasonable length of time before occupation, if possible during the night. But then again, care must be taken that the walls are not being cooled so much so as to cause a precipitation of any moisture from the air in the room upon the cooled wall surfaces. In all such cases, therefore, it is preferable to cool as much as possible of the walls to a moderate degree than to cool a mere skin of the walls to an extreme low degree, or in other words, to maintain a temperature of the air in the room of 60 degrees F., or a temperature not much below that during the period of cooling, and to prolong this period as much as possible.

It is well known that a moderately low temperature prevails at a certain depth below the surface of the earth and that this temperature is nearly uniform throughout the whole year. The idea of utilizing this condition is but natural and logical. In fact, there are several plants for the cooling of air in existence by which the air is conducted through a series of ducts arranged in that cool stratum. The effect of such arrangements, however, is very un-

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certain and actually decreases in course of time, especially when the soil is very dry. Even with the ducts below the level of the ground water, the obtainable effect is rarely such as to justify the great cost of such an arrangement.

The use of water as a means for cooling the air has been tried repeatedly and in various ways. For instance, by bringing the air in contact with surfaces which are kept wet by a continuous thin stream of water over their entire surface. This is sometimes arranged so that the water supply can be stopped for a while and the air allowed to come in contact with the now dry surfaces but previously cooled by the water running over them. Of course, after a certain time the water has to be turned on again. Such arrangements naturally require constant and judicious attendance, which besides their low efficiency, exclude them from a more general application. An improvement is to use the water in sprays of more or less fineness. Then the cooling of the air is accomplished not only by the contact of the air with the water, but also by the unavoidable evaporation of the water, whereby a certain quantity of heat becomes latent when the water changes its state from the liquid to the vaporous. The disadvantage of this mode of cooling is that the cooled air becomes so saturated with moisture that in most cases a supplementary drying of the air cannot be avoided, which greatly increases the cost of the plant as well as the running expense.

The use of ice may be justifiable for the cooling of small rooms, especially when the price of the ice need not be taken into consideration. But then it is advisable to arrange the cooling chamber above the room to be cooled and to introduce the cooled air into the room from above. In reference to the efficiency of this mode of cooling, it may be stated here that by the melting of one pound of ice, 142.4 B. T. U. are absorbed, of which the following example gives a fair illustration:

Supposing 10000 cubic feet of air per hour were to be cooled from 90 to 60 degrees F., a difference of 30 degrees, how many pounds of ice would be required?

The weight of one cubic foot of air at 90 degrees F. equals

$$\frac{0.0807}{1 + 0.00204\,(90 - 32)} = 0.0721$$ pounds, and the specific heat of air is to be taken as 0.2379.

Hence, $10000 \times 0.0721 \times 0.2379 \times 30 = 515$ B. T. U. which have to be absorbed by the melting ice per hour, which requires

$$\frac{515}{142.4} = 3\tfrac{5}{8}$$ pounds every hour.

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Of the cooling arrangements with water or ice, so far, only those have been considered which require a direct contact of the air with the cooling medium. The many disadvantages of these modes are avoided to a great extent by bringing the air in contact with such cooling surfaces as are themselves cooled by some medium without bringing this cooling medium in direct contact with the air to be cooled.

The water from a public water supply is excluded as a cooling medium on account of its cost and its usually high temperature. Spring water requires special lifting machinery and so much cooling surface as rarely can be accommodated, and ice water cannot be considered on account of the cost. Modern practice, therefore, applies special refrigerating machines for the cooling of the water, which, when serving as the cooling medium, usually contains salt in solution to enable the reduction of its temperature to a degree as low as possible. The principle of the refrigerating machines generally applied is that based on the vaporization of certain liquids caused by a reduction of pressure.

By this process the heat absorbed is withdrawn from the saline solution surrounding the vessel in which the vaporization takes place. The reduction of temperature of the saline solution or brine will be greater the greater the reduction of pressure and the lower the boiling point of the liquid employed.

Another method of cooling is to discharge into the room highly compressed air, which, in expanding, will greatly reduce its temperature. This mode of cooling, however, will not find any consideration in practice on account of the expensive machinery required for the compression of air, since the air while being compressed must also be cooled, unless compressed air can be supplied by a central air compressing plant at a reasonable price. No doubt, should compressed air ever become a factor in the industries, the importance of this mode of cooling of rooms in summer time is apparent.

As to the material of the cooling surfaces, it is obvious that it must not be effected by the precipitated water, nor otherwise corrode. Bare iron surfaces are therefore excluded, unless they are made rust proof in a reliable way, either by inoxidizing, that is, by exposing the wrought iron pipes, heated to a red hot state, to the action of steam, in which case the cooling surfaces may also serve as heating surfaces during the heating season, or by coating the moderately heated pipes by immersion in hot tar or asphaltum. Sometimes the cooling surfaces are made of copper which, in special cases, may be even compulsory.

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Comparing all the arguments for and against the various systems of cooling arrangements, it will be found that only those arrangements which, in their principle, are based on the introduction of cooled air into the rooms to be cooled are of practical value.

It is evident that the lowest temperature of the entering cooled air can not be assumed below a certain limit without sacrificing the bodily comfort of the occupants. Furthermore, it is not advisable to introduce a larger quantity of air per hour than five times the cubic contents of the room, lest annoying drafts be created. Between these two limits it is seldom possible to counteract the excess of heat in the room solely by the cooled air introduced. In such cases, then, it becomes necessary to utilize the walls as supplementary cooling surfaces by cooling them before the occupation of the room.

On making the necessary calculations, it will be found that it is more convenient to represent the quantity of air under consideration by its weight in pounds, which is readily found by the formula

$$A = C \frac{0.0807}{1 + 0.00204\,(t - 32)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which C is the quantity of air in cubic feet per hour, A the weight of this quantity of air in pounds, and t the temperature of the air.

The temperature which is to prevail during the occupation of the room is always decided upon beforehand, and is assumed to be uniform throughout the room at the height of a man's head; towards the ceiling, however, the temperature is always higher, and there, according to Prof. H. Fischer may be taken at:

$$T_1 = T \left[1 + 0.0051\,(h - 9) \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (2a)$$

for temperatures not below 50 degrees F. and without heat producing illumination; otherwise at

$$(T_1 = T \left[1 + 0.017\,(h - 9) \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (2b)$$

but not exceeding $T_1 = 1.5\ T$. In formulas (2a) and (2b), T is the temperature at the height of a man's head above the floor, T_1 the temperature at the ceiling, and h the total height of the room in feet.

The mean temperature of the room, upon which further calculations are based, is then, accordingly:

$$t_0 = \frac{T - T_1}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2c)$$

The quantity of heat transmitted from the outside through the

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walls, in the following represented by H_1, is calculated in the same way that the loss of heat by transmission is calculated for a heating apparatus, and is based on the difference between the mean highest outside temperature of the locality t and the mean temperature of the room t_0.

The quantity of heat generated by the occupants and any other sources has already been referred to, and can be readily ascertained from the given data. In the following, H_2 may represent the quantity of heat generated by the occupants and H_3 that by other sources.

The total quantity of heat to be counteracted by the cooling apparatus is then:

$$H = H_1 + H_2 + H_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

If this heat is to be absorbed by the cool air introduced, the necessary air supply to be provided for must be:

$$A_0 = \frac{H}{0.2379\,(t - t_0)} \text{ pounds} \quad \ldots\ldots\ldots\ldots\ldots (4a)$$

$$\text{or } C_0 = \frac{A_0}{0.0807}\left[1 + 0.00204\,(t_0 - 32)\right] \quad \ldots\ldots\ldots (4b)$$

if expressed in cubic feet. For reasons already assigned, the total air supply must not be more than five times the cubic contents of the room, and whenever the air supply as calculated according to (4 b) is beyond that limit, the maximum air supply is then taken equal to five times the cubic contents of the room and the remaining uncovered excess of heat must be absorbed by the walls of the room, provided these walls are of sufficient thickness for that purpose, in which case they must be cooled before the room is occupied.

The next would be to determine the quantity of moisture generated by the occupants and the illumination. According to "Fluegge's Hygienic Researches," the average generation of aqueous vapor by an adult is 0.0794 pounds and by a child 0.0331 pounds per hour. F. Fischer, in his "Furnace Construction," states that by the combustion of one cubic foot of gas 0.0624 pounds or one ounce of aqueous vapor is generated and immediately absorbed by the air.

The total quantity of aqueous vapor which must be absorbed by the air in the room may be represented by W. This quantity W determines the limit of the absolute humidity of the entering air. If the latter is represented by M,

$$M = A_0 w_0 \frac{p_0}{100} - W \quad \ldots\ldots\ldots\ldots\ldots\ldots (5a)$$

wherein p_0 is the percentage of saturation allowed (relative hu-

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midity) of the air in the room, w_0 the weight of moisture (in pounds) contained in one pound of air at the temperature t_0 when saturated.

The value of w_0 may be ascertained from the equation:

$$W = 0.0209\ E \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5b)$$

wherein E represents the elastic force of the aqueous vapor at the temperature t_0.

The equation (5b) may be derived by the following development:

Let V denote a certain volume of moist air, B its pressure, expressed by the height of a column of mercury in inches (Barometer reading), E the elastic force of the aqueous vapor in it, also expressed by the height of a column of mercury in inches, and t the temperature of the air. The entire gaseous mass may be divided into two parts, a volume V′ of dry air at the temperature t and the pressure B—E, whose weight is, by the known formula of expansion

$$w' = V \frac{0.0807}{1 + \alpha (t - 32)} \frac{B - E}{29.9213} \text{ pounds} \ldots\ldots\ldots\ldots (a)$$

and a volume V″ of aqueous vapor at the same temperature t and the pressure E, the weight of which is:

$$w'' = \tfrac{5}{8} V \frac{0.0807}{1 + \alpha (t - 32)} \frac{E}{29.9213} \text{ pounds} \ldots\ldots\ldots\ldots (b)$$

The sum of these two weights is the weight of the volume V of saturated air, viz.:

$$w''' = V \frac{0.0807}{1 + \alpha (t - 32)} \frac{B - \frac{3}{8} E}{29.9213} \text{ pounds} \ldots\ldots\ldots\ldots (c)$$

which shows that moist air actually weighs less than the same volume of dry air. In practice, however, where always the most unfavorable conditions must be considered, the weight of air usually is figured as that of dry air, as shown by equation (1).

According to equation (b), one cubic foot of saturated air at the temperature t contains $\frac{5}{8} \frac{0.0807}{1 + \alpha (t - 32)} \frac{E}{29.9213}$ pounds of moisture, and according to our supposition one cubic foot of saturated air at the temperature t weighs $\frac{0.0807}{1 + \alpha (t - 32)}$ pounds; in consequence thereof one pound of saturated air contains:

$$w = \frac{\frac{5}{8} \frac{0.0807}{1 + \alpha (t - 32)} \frac{E}{29.9213}}{\frac{0.0807}{1 + \alpha (t - 32)}} = \tfrac{5}{8} \frac{E}{29.9213} = 0.0209\ E \text{ pounds of}$$

moisture. As already stated, the value of w by equation (5b) is only approximate, but for all practical purposes it is sufficiently ac-

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curate to be more subservient than its actual value as derived by dividing equation (b) by the equation (c), viz.:

$$w = \frac{\frac{5}{8} E}{B - \frac{3}{8} E} \text{ pounds.}$$

The value of E for the various temperatures is found in any standard text-book treating on the subject of heat. (Box, Stewart, and many others.)

The quantity of moisture M, as ascertained by equation (5a), in turn determines what quantity of moisture must be extracted from the air while passing through the cooling apparatus. Representing the latter by Q, its quantity must be:

$$Q = A_0 \frac{p\,w}{100} - M \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

when p is the relative humidity of the outside atmosphere and w the weight of moisture (in pounds) contained in one pound of outside air at the temperature t_0 when saturated.

Now must be determined to what temperature t_1 the fresh air from the outside must be cooled in order to contain not more than M pounds of moisture.

Here two distinct cases are to be considered. First the total air supply of A_0 pounds is to be cooled from t degree to t_1 degrees:

$$\text{in that case: } M = A_0 \frac{p_1 w_1}{100} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7a)$$

$$\text{from which follows } w = \frac{100\,M}{A_0\,p_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7b)$$

when p_1 is the relative humidity of the air at t_1 degrees and w_1 the weight of moisture (in pounds) contained in one pound of air at t_1 degrees when saturated; p_1 must be assumed, but in most cases, and especially so when the relative humidity of the outside atmosphere is very high (above 75 per cent), can be taken as 100 per cent. After ascertaining the value of w_1 from the equation (7b) the corresponding value of t_1 is found by ascertaining, first the value for E_1 from the equation (5b) and then taking the corresponding value of t_1 from the table already referred to.

The temperature t_1 thus determined may also represent the maximum temperature of the cooling medium (saline solution or brine), and as such determines the necessary cooling surface, which naturally will be the greater, the higher the temperature of the brine. In practice, however, it is always desirable to have the cooling surfaces as small as possible but that again necessitates a lower temperature of the brine.

This leads to the second case, where only a certain part A_1 of

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the total air supply A_0 is to be cooled, which afterward is mixed again with another part A of uncooled air. In this case the initial and final temperatures of the brine are decided upon beforehand, usually allowing a rise of temperature of about 20 degrees. The maximum or final temperature of the brine then may be also that temperature to which the part A_1 of the air supply is to be cooled, but not necessarily so. Thus it will occur that in most cases the so cooled air will be nearly, if not fully, saturated with moisture before it is mixed with the quantity A of uncooled air. After the mixing the temperature of the mixture will be higher than that of the cooled part of the air, but there will be still a further precipitation of moisture from the mixture of air, owing to the presence of the moisture in the quantity A of uncooled air, which will increase the temperature of the mixture still more, as the mixture must also absorb the latent heat of vaporization of the precipitated quantity of water. In order to simplify the otherwise quite complicated calculations, it is advisable to assume the quantity of air A_1 so that a sufficient quantity of moisture can be precipitated to justify the neglect of the supplementary heating of the mixture caused by the precipitation of moisture while the mixing of the two parts of the air supply takes place. The result of this will be that the relative humidity of the mixture will be somewhat lower than required.

Under these suppositions the temperature t_1 is decided upon, the corresponding value of w_1 ascertained by equation (5b) after the value for E therein has been taken from the same table already referred to, and p_1 is assumed according to the prevailing relative humidity of the outside atmosphere (usually $p_1 = 100$).

$$\text{Then, } A_1 = \frac{100\ M}{pw - p_1 w_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$\text{Furthermore } A = A_0 - A_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

and the temperature of the mixture

$$t_2 = t - \frac{A_1}{A_0}(t - t_1) \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

The relative humidity of the air which will actually prevail in the room during its occupation, in case the total air supply is being cooled to the temperature t_1, will not be beyond the limit set, while in a case where only a part of the total air supply is cooled and afterwards mixed with another part of uncooled air, the prevailing humidity of the air in the room during its occupation will be:

$$p_0 = \frac{(A_0 w_2 + W)\ 100}{A_0 w_0} \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

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The corresponding values of w_0 and w_2, that is the quantity of moisture (in pounds) contained in one pound of air at the temperatures t_0 and t_2 respectively when saturated are found from the table after ascertaining the elastic force of the vapors from the equation (5b).

As to the quantity of heat to be absorbed by the cooling surfaces, it has already been pointed out that the latent heat of the precipitated water must not be neglected. In consideration thereof, the total quantity of heat to be absorbed amounts to

$$H = QP + 0.2379\ A_0\ (t - t_1) \ldots\ldots\ldots (12)$$

when the total air supply A_0 is to be cooled, and to

$$H = QP + 0.2379\ A_1\ (t - t_1) \ldots\ldots\ldots (13)$$

when only the part A_1 of the total air supply is to be cooled. In equations (12) and (13), P represents the latent heat of vaporization of water at the temperature t_1, the value of which, expressed in B. T. U., can be ascertained by Regnault's formula, viz:

$$P = 1115.2 - 0.708\ t = \text{B. T. U.} \ldots\ldots\ldots\ldots (14)$$

The determination of the quantity of heat to be absorbed by the cooling surfaces leads to the determination of the cooling surfaces themselves. For cooling purposes it is always advisable to arrange the cooling surfaces so that the air passes the apparatus in a direction opposite to that of the flow of the cooling medium. (Counter current system.) The co-efficient of transmission k, that is, the quantity of heat transmitted through one square foot of surface per degree of difference of temperatures, varies considerably, and the prevailing conditions as to the velocity of the air passing the apparatus, the more or less wet condition of the outer surface of the coils, etc., must be taken well into consideration. If the surfaces are apt to remain dry, the value of k may be taken at 2.5, but if there is any precipitation of moisture to be expected or required, a value of k = 3.00 will not be too high. Of course, these values of k are more or less approximate, and the application of the proper value of k to suit the special conditions under consideration depends entirely upon the judgment and experience of the designer, who must consider all conditions, the known as well as those to be expected.

The required cooling surface is best determined by the following equation:

$$S = \frac{1}{k} \frac{H}{(t - \delta_1) - (t_1 - \delta)} \log \text{nat} \frac{t - \delta_1}{t_1 - \delta} \ldots\ldots\ldots (15)$$

wherein δ is the temperature of the brine when entering the coils and δ that when leaving; S represents the required cooling surface in square feet. In order to avoid the use of the log nat in

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equation (15) the latter may be transformed into:

$$S = \frac{1}{k} \frac{H}{(t - \delta_1) - (t_1 - \delta)} 2.3026 \log \frac{t - \delta_1}{t_1 - \delta} \quad \ldots\ldots\ldots (16)$$

since: 2.3026 log vulg a = log nat a.

The following example will give a fair illustration of the necessary calculations for a cooling apparatus, the data being as follows:

A hall 65 feet long, 40 feet wide, 33 feet high, and provided with electric illumination is used for the occasional assemblage of about 200 persons. During the occupation of the hall, which, however, may not be for more than three hours at a time, the temperature in the hall shall not exceed 72 degrees. The mean highest outside temperature of the locality to be 86 degrees and the temperature of the cooled air entering the hall shall not be below 62 degrees. At a relative humidity of 80 per cent of the outside atmosphere, the relative humidity of the air in the hall must not exceed 50 per cent. The temperature of the hall before the beginning of the cooling may be 79 degrees.

The transmission of the heat from the exterior to the interior has been calculated for a difference of temperature 86 — 72 = 14 degrees and found to be equal to 38000 B. T. U. per hour.

The actual air supply during the occupation must not exceed 1400 cubic feet per hour for each person; the cooling of the hall before its occupation is to be accomplished by a return circulation of the air.

For the solution of this problem it is most convenient to proceed in the following way:

The temperature in the room at the height of a man's head is T = 72 degrees and the temperature at the ceiling, according to equation (2a), $72 \left[1 + 0.0051 \times (33 - 9)\right] = 80.8$ or 81 degrees, consequently the mean temperature in the hall

$$t_0 = \frac{72 + 81}{2} = 76\tfrac{1}{2} \text{ degrees}$$

which may be taken as 77 degrees.

The transmission of heat from the outside, as calculated, is $H_1 = 38000$ B. T. U.

The generation of heat by the occupants amounts to

$$H_2 = 200 \times 13.2 \ (99 - 72) = 71280 \text{ B. T. U.},$$

while the heat which is generated by the electric illumination may be neglected.

The total quantity of heat which is to be absorbed during the occupation of the hall is, then:

$H = H_1 + H_2 = 38000 + 71280 = 109280$ B. T. U. per hour.

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The necessary air supply for the hall is determined by equation (3), viz:

$$A_0 = \frac{109280}{0.2379\ (77 - 62)} = 30623.5 \text{ pounds}$$

$$\text{or } C_0 = \frac{30623.5}{0.0807}\left[1 + 0.00204\ (70 - 32)\right] = 408858 \text{ cubic feet per hour}$$

which is equivalent to $\frac{408858}{200} = 2044$ cubic feet of air per person, which is far in excess of the limit set for the air supply. As the latter shall not be more than 1400 cubic feet per person, the total air supply to the hall must not be more than $200 \times 1400 = 280000$ cubic feet or 20972 pounds per hour, which allows the air in the hall to be changed about $3\frac{1}{4}$ times per hour.

By means of this air supply only $20972 \times 0.2379\ (77—62 = 74840$ B. T. U. will be absorbed, and, as 109280 B. T. U. must be taken care of, $109280 - 74840 = 34440$ B. T. U. must be absorbed by the walls, which, of course, requires their cooling before the occupation of the hall.

As electric illumination is provided for the hall, only the generation of moisture by the occupants need be considered, which, in our case, amounts to $W = 200 \times 0.0794 = 15.88$ pounds per hour.

One of the conditions of the problem is that during the occupation of the hall the relative humidity of the air therein shall not exceed 50 per cent. Now, one pound of air at 72 degrees, the temperature which is to be maintained in the room, by equation (5b) contains

$$w_0 = 0.0209\ E_0 = 0.0209 \times 0.7841 = 0.01639 \text{ pounds}$$

of moisture when saturated, consequently by equation (5a), the air supply during the occupation of the room must not contain more than

$$M = 20972 \times 0.01639 \times \frac{50}{100} - 15.88 = 156. \text{ pounds}$$

of moisture per hour, which necessitates that, by equation (6),

$$Q = 20972 \times 0.0209 \times 1.2413 \times \frac{80}{100} - 156 = 279.26 \text{ pounds}$$

of water must be precipitated by the cooling surfaces per hour from the air while being cooled (1.2413 = E at 86 degrees).

The next proceeding will be the determination of the temperature t_1 to which the entering fresh air must be cooled so as not to contain more than 156 pounds of moisture.

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Supposing the entire supply of 20972 pounds were to be cooled, then, by equation (7),

$$156 = 20972 \times w_1 \times \frac{p_1}{100}$$

In this case, where the relative humidity of the outside atmosphere at a temperature of 86 degrees is already as high as 80 per cent, the value of p_1 can safely be taken at 100, which makes

$$w_1 = \frac{156}{20972} = 0.00744 \text{ pounds,}$$

from which follows: $E_1 = \frac{0.00744}{0.0209} = 0.3560$ inches.

and corresponding thereto from the table, $t_1 = 50°$ F. Such high cooling temperature requires naturally larger cooling surfaces than are desirable in practice, and therefore it is preferable to use as a cooling medium a saline solution at such a temperature that only a part of A_1 of the total air supply of 20972 pounds is being cooled from 86 to 32 degrees and afterwards mixed with another part A of uncooled air. At a temperature of 32 degrees the elastic force of vapor is $E_1 = 0.1810$ inches, and, as a precipitation of water takes place: $p_1 = 100$. Then, by equation (8)

$$A_1 = \frac{100 \times 279.26}{80 \times 0.0209 \times 1.2413 - 100 \times 0.0209 \times 0.181} = 16455 \text{ pounds}$$

which, after cooling, must be mixed with $A = 20972 - 16455 = 4517$ pounds of uncooled air, the temperature of the mixture being

$$t_2 = 86 - \frac{16455\,(86 - 32)}{20972} = 44 \text{ degrees.}$$

The elastic force of vapor at the temperature $t_0 = 77°$ is $E_0 = 0.9266$, and at $t_2 = 44$ is $E_2 = 0.2880$ consequently the prevailing relative humidity of the air in the hall during the occupation will be, according to equation (11).

$$p_0 = \frac{(20972 \times 0.0209 \times 0.2880 + 15.88 \times 100)}{20972 \times 0.0209 \times 0.9266} = 35 \text{ per cent.}$$

The latent heat of vaporization for water at 32 degrees F. by Regnault's rule or equation (14) being

$$P = 1115.2 - 0.708 \times 32 = 1092 \text{ B. T. U.,}$$

the total quantity of heat to be absorbed by the cooling surfaces is then, according to equation (13),

$H = 279.26 \times 1092 + 0.2379 \times 16455 \times (86 - 32) = 516343$ B. T. U.

Had the entire air supply of 20972 pounds been cooled to 50 degrees, in which case

$$P = 1115.2 - 0.708 \times 32 = 1078 \text{ B. T. U.,}$$

that quantity of heat would be:

$H = 279.26 \times 1078 + 0.2379 \times 20972 \times (86 - 50) = 480655$ B. T. U.

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By determining the necessary cooling surface in the one case, where 16455 pounds of air are to be cooled from 86 to 32 degrees, the initial temperature of the cooling medium (brine) may be assumed at 14 degrees and its final temperature at 32 degrees. Then, according to equation (16)

$$S = \frac{1}{3} \times \frac{516343}{(86-32)-(32-14)} 2.3026 \log \frac{86-32}{32-14} = 5252 \text{ sq. ft.},$$

while in the other case, where the entire air supply of 20900 pounds is to be cooled from 86 to 53 degrees, the necessary cooling surface for an initial temperature of the cooling medium of 32 degrees and a final temperature of 53 degrees would be

$$S = \frac{1}{2.5} \times \frac{480655}{(86-50)-(50-32)} 2.3026 \log \frac{86-50}{50-32} = 7338 \text{ sq. ft.},$$

which is considerably in excess of the necessary surface in the former case.

As already stated, the total quantity of heat to be taken care of during the occupation of the hall was 109280 B. T. U., and 74840 B. T. U. of this quantity being absorbed by the entering cooled air; the rest—34440 B. T. U.—must be absorbed by the walls. For this purpose the walls must be cooled before the occupation of the hall, and at the same time the temperature of the air therein must be reduced from 79 to 72 degrees. Considering this pre-cooling of the hall as a negative warming up, an empirical rule, derived by Prof. A. Rietschel from the results of 25 heating apparatus for churches, can be well applied for the calculation of the quantity of heat to be absorbed in order to reduce the temperature of the air in the hall. This rule reads as follows:

$$0.5\, G\, k\, (t - t_0) + W \left[8.5 + \frac{t_1 - t_0}{Z} \right] = \text{B. T. U.}$$

in which G represents the square feet of glass surface, W the square feet of wall surface, k the co-efficient of transmission for glass, t the temperature of external air, t_1 the temperature of internal air before cooling, t_0 the required temperature in hall, Z the time allowed for cooling in hours.

In the case under consideration the glass surface being 1050 square feet and the wall surface being 10760 square feet, the quantity of heat to be absorbed is then, with k = 1,

$$0.5 \times 1050 \times (86-72) + 10760 \left[8.5 + \frac{79-72}{Z} \right] = 98810 + \frac{75320}{Z} = \text{B. T. U.}$$

per hour.

In addition to this the walls must be also sufficiently cooled so as to absorb during the occupation of the hall 34440 B. T. U. per hour, or in total $34440 \times 3 = 103320$ B. T. U.

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The total quantity of heat which must be absorbed by the cooling air per hour is therefore:

$$98810 + \frac{75320}{Z} + \frac{103320}{Z} = \text{B. T. U. per hour.}$$

which, for Z = eight hours, amounts to:

$$98810 + \frac{178640}{8} = 121140 \text{ B. T. U. per hour.}$$

The cooling surface has been determined before, viz: S = 5252 square feet and the wall surface being 10760 square feet, the quantity before its occupation is to be accomplished by the return circulation of the air in the hall. The relative humidity of the air in the hall during occupation shall not exceed 50 per cent, which limit may also be assumed for the cooling period before occupation, thus avoiding any precipitation of moisture upon the walls, etc. The relative humidity of the air in the hall before the beginning of the cooling being the same as that of the outside atmosphere, 80 per cent, leaves 30 per cent of moisture to be precipitated by the cooling surfaces. The mean temperature in the hall during the cooling period will be:

$$\frac{79 + 72}{2} = 75\tfrac{1}{2} \text{ degrees}$$

which may be taken as 76 degrees. The elastic force of vapor at this temperature being E = 0.8964, and the hall containing about 85800 cubic feet of space, the total quantity of moisture to be extracted from the air in the room is then:

$$\frac{85800 \times 0.0807}{1 + 0.00204\,(76 - 32)}\, 0.0209 \times 0.8964 \times \frac{30}{100} = 35.7 \text{ pounds}$$

which must be accomplished during the eight hours allowed for cooling. Though not exactly right, it is sufficiently accurate to assume that the precipitation of this quantity of water takes place at the rate of

$$\frac{35.7}{8} = 4.46 \text{ pounds per hour.}$$

As to the temperature of the entering cooling air, it is advisable to assume this temperature so that the entering air, even if saturated, cannot contain more moisture than air at 72 degrees with a relative humidity of 50 per cent. Taking the temperature of the entering air at 50 degrees, the latent heat of vaporization at that temperature being 1115.2 — 0.708 × 50 = 1080 B. T. U., the total quantity of heat to be absorbed by the cooling surfaces will be 121140 + 4.46 × 1080 = 125957 B. T. U. at a mean temperature of the air in the hall of 76 degrees, and the cooling

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air entering at a temperature of 50 degrees the necessary air supply or change of air per hour must be:

$$A^1_0 = \frac{121140}{0.2379\ (76 - 50)} = 19520 \text{ pounds.}$$

This quantity of air corresponds nearly with the necessary air supply during the occupation of the hall, which is very favorable on account of the air supply ducts.

By means of the available cooling surface of 4976 square feet being determined by other conditions, the temperature of the cooling medium must be determined. By equation (15) it must be:

$$5252 \gtrless \frac{1}{k} \frac{125957}{(t_0 - \delta^1_0) - (t^1_0 - \delta_0)} 2.3026 \log \frac{t_0 - \delta^1_0}{t^1_0 - \delta_0}$$

wherein: $t_0 = 76^0$, $t_0{}^1 = 50^0$, and $k = 2.5$ while δ_0 the initial and $\delta_0{}^1$ the final temperature of the brine are to be ascertained. The foregoing equation can be solved by trial. So, for instance, for $\delta_0 = 40^0$ and $\delta_0{}^1 = 46^0$ it is

$$\frac{1}{2.5} \frac{125957}{(76 - 46) - (50 - 40)} 2.3026 \log \frac{76 - 46}{50 - 40} = 2768 < 5252$$

In this case the pre-cooling period must be reduced, and the change of air increased, which, however, is not practicable on account of the air ducts. With $\delta_0 = 43^0$ and $\delta^1_0 = 63^0$ it will be $5252 > 5198$ which values are so nearly equal that the assumed temperatures of the brine may be retained. Resuming the various results so far obtained we find that under the supposition of return circulation of the air during the pre-cooling of the hall the air therein must be changed so often that 19520 pounds of air, which previously had been cooled from 76 to 50 degrees, are being introduced per hour. The time allowed for the cooling was eight hours; during that time the initial temperature of the brine must be 43 degrees and its final temperature 63 degrees after which time the temperatures of the brine must be reduced to 14 and 32 degrees respectively, when every hour 16455 pounds of air must be cooled from 86 to 32 degrees. The required cooling surface was ascertained to be 5252 square feet.

In concluding I might say that, though these calculations are more or less approximate, as in most cases the conditions can be considered only in an average, and in certain conditions as the presence of moisture in the walls, etc., are rarely considered at all, the obtained results can safely be relied upon.

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DISCUSSION.

Mr. Hoffman:—Isn't it a fact that the humidity of the air has a good deal to do with the sensation of a person as to being cool or not? Say that the air be saturated at 70 per cent, a person feels a good deal warmer than he would if the air was saturated only to 50 per cent.

Mr. Eisert:—That warm feeling is nothing but an uncomfortable feeling; you cannot perspire.

Mr. Hoffman:—Well, a very active perspiring is an active cooling, is it not?

Mr. Eisert:—Certainly. But you cannot perspire if the air is too highly saturated.

Mr. Hoffman:—And when the air is not fully saturated you can perspire, and therefore the sensation is one of comfort to yourself; is not that the fact?

Mr. Cary:—This is a very interesting paper and is a subject, as Mr. Eisert has said, that will have to be taken up very soon. I think it is taken up somewhat now. I think our Western friends are a little ahead of us. The matter of cooling rooms has been taken up at Kansas City, and in that place there is a large central refrigerating plant having pipes conducted through the streets and there are several stores which are connected with it. I think it is a brine system—the circulation of brine through the streets. They are taking that in their stores and cooling them. In Denver, I believe, that is also done, and something of the kind has been attempted in St. Louis. I have understood that one or two of the drug stores have had their places cooled by that system on warm days, and people can come in there and refresh themselves by being in a cooler atmosphere as well as by drinks that are dispensed there. The matter of humidity is one of the greatest importance. I asked the manager of one of the largest refrigerating concerns in the country some questions about cooling buildings—its practicability. He said cooling the buildings had very little to do with the question; that if you would merely remove the moisture in the air and reduce the percentage of humidity you would gain the object you seek for a good deal better than by cooling the room, and he told me that the concern he was connected with had made some experiments in that line. I refer to the Frick Machine Company. They had not found it up to the present time profitable to go into isolated work. On humid days, when the percentage of humidity is very high, then the air is pretty nearly saturated with moisture, pretty well up towards the dew point. It cannot take care of any more moisture. We perspire and the perspiration remains on the body:

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whereas if the air is free from an excess of moisture, the perspiration evaporates and passes into the air, and we have a less oppressed feeling than we would if the temperature was cool and the humidity not removed. That is the first thing to get at. I believe that there is a house in Twenty-third street in this city, between Seventh and Eighth avenues, that was cooled during one or two summers. People were invited there; it was open to the public, but I believe it was some kind of a speculation scheme to get money more than anything else, and it was not practical. But the house was really cooled some ten or twelve degrees below the outside air and I suppose they looked out for the humidity, as that is necessary in order to produce good results.

The figure of thirty to thirty-five cents as the cost per hour for cooling a room in which there are 200 persons I am afraid is rather low. There has been a good deal of experimenting in these days and it has run very much over that figure. It would be eight or ten times that amount, I am afraid, from what inquiries I have made. I think that this is a matter that wants to be looked into a good deal by the society. We have a good many wealthy men coming to this city, putting up beautiful houses and looking out for every comfort, and a great many wealthy men in other cities are doing the same thing, and they are adopting everything that they can in their residences to promote their personal comfort and are willing to spend a great deal of money for that end. We have been going on and perfecting the warming of our buildings and incidentally ventilating them and we have done very little, or nothing, in the other direction. I think it is only a question of time before that will have to be taken up and gone into just as much as the heating, and I believe that we will find our windows closed in winter with the heat behind them to keep them comfortable, and in the summer the windows closed against the heat outside. The first plants installed will necessarily be very expensive, but I think that we have got to the time when there are plenty of wealthy men putting up elegant residences with every convenience in them and who do not stand at any expense at all, and I think they are willing to become the victims of the experimental stage of this work. I think the sooner it is taken hold of the sooner somebody will reap very profitable results.

Mr. Jellett:—This is a subject that the average heating or ventilating engineer knows very little about, and one reason I take it is that he has never been called on as yet to use his thinking cap in this particular direction. I am very much interested in the paper of Mr. Eisert, but it is a paper that cannot be read and discussed

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offhand. It requires a great deal of study to get to the bottom of it, and when you get to the bottom you find that there is a hole in the bottom and you have to go further. I have had some little experience in cooling rooms, but I have never yet cooled them with a refrigerating machine, though I have cooled them in other ways. The first time I was called in for any work of that kind was in connection with the manufacture of glue. The average factory in this country makes glue from the first of October until about the first of May. The rest of the year the plant is shut down. The reason for that has been that in summer weather the temperature is so high that you cannot get the glue to set and harden. At a temperature of 90 degrees the glue will remain soft and it cannot be dried. Therefore it became necessary, if the business was to be carried on through the summer months, to find some method of drying the glue. My first experience in that particular direction was in a factory that is not now in existence; this was some nine or ten years ago. We had a case where the parties had a great deal of work on hand, but on account of weather they were obliged to shut down. I was consulted about the matter and asked if anything could be done. I said "you have to warm your air to a certain point in order to dry the glue; why not cool it in summer?" After the glue is once coated, that is, given a skin in the dry room, it will stand a much higher temperature. We experimented on it by taking a large boxed coil of steam pipe. We put up a brine tank, used an old tank pump, and we circulated the brine through this coil. We drew the air over the coil by means of a fan, and the moisture in the air was condensed against the surface of the coil; the temperature was reduced some twelve degrees. The temperature outside was 86 degrees, and we brought it down to about 75 or 76 on an average. The air was then returned into the alleys again, the volume of air being used over and over again with a very slight admission of fresh air. We found we got very good results. Other glue manufacturers, who told me frequently that it could not be done, told me afterwards that glue was on the market and that it was fresh glue, implying that it had been made in summer weather.

Later on I had a fan system of heating in a large work shop in Philadelphia. The shop was situated in a valley where the sun seemed to beat down with unusual intensity and there was no cross circulation of air. The superintendent said to me that he was having a great deal of trouble with the heat, and wondered if some way outside of artificial refrigeration could not be devised to lower the temperature of the shops. I found that the temperature of the city

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water at that point was pretty low. I suggested to him as a means of lowering the temperature of the shop, that he connect the city water with the fan heater and allow it to circulate and that he should run the blower in summer time and draw the air over the surface of the coils. We found that this lowered the temperature about six degrees and the air in the shops became much more comfortable. It was necessary to keep the side windows closed on account of dust from passing trains. Therefore they got very satisfactory results, though the drop in temperature was not very great—from five to six degrees.

The artificial cooling of rooms by refrigerating processes, I think, is going to be a very difficult matter. It is possible to cool a room to almost any point you please. But there is a question of danger that comes in. They have in Pittsburgh at the present time a summer skating rink. There is one in New York. I do not know whether it is open yet or not, but my friends tell me that it is very dangerous to skate in that particular way. The temperature outside may be 80 or 85. They come into the room at a low temperature and skate on artificial ice. Then they go out. The result is that persons subject to rheumatism and such ailments suffer.

I think the question that Mr. Eisert raises of the humidity of the air is one that will bear the closest investigation. I believe that if we make the drop too decided between the outside and the inside it would be a decided danger. I have had some experience in fermenting houses and brewery work and there is a great accumulation of carbon dioxide. I was called on to ventilate a large beer cooling house some time ago, the reason for the request being the fact that one of the workmen was overcome with gas on going in in the morning. We found that the melting of ice was very considerable if the air was to be changed rapidly. The matter was referred to an expert in refrigerating matters. We were asked to move a given volume of air through the room and he was asked to say what the effect would be on the machine. He reported that the cooling of that volume of air from a temperature of 80 degrees to the point at which the room was supposed to be carried, namely about 34, meant the melting of fifteen tons of ice a day in that particular house. It was a matter outside of consideration on account of its cost. Now I take it that the object of Mr. Eisert's paper is the cooling of rooms in which people are assembled. I do not think the matter of a dwelling house enters into it at all, because the man who can afford to put this apparatus in can afford to go away in warm weather into a different climate. It is for people that assemble in large halls, sick people in hospitals, and

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other places, where there are large assemblies, and where it is very desirable to reduce the suffering from the heat, that cooling arrangements are desirable, and the questions coming in are very difficult to handle. The lowering of temperature by artificial means is a very broad subject, and I am not prepared to say that I am very sanguine of success in artificially cooled temperatures. If the entire air supply could be kept at a uniform temperature, that would be something desirable, but to have to come from a low temperature to a high would create results that I am satisfied are utterly unlooked for and results that would probably kill the scheme. But cooling within a reasonable range can be done. My own idea of cooling a room of this kind would be that there should be a maximum volume of air at a very slightly reduced temperature, the volume of air creating the cool effect on the body without having extreme changes of temperature.

Mr. Eisert:—I made just the very point in the paper that the air should not enter the room at a lower temperature than six degrees, and then entering near the ceiling it will spread out and uniformly settle down, so that a uniform temperature of about 70, 72 or 73 degrees is maintained in the room.

Mr. Payne:—In regard to Mr. Jellett's point of its being injurious to go from a low temperature to a high, if the room were cooled ten degrees below the outside temperature, I hardly think it would be as injurious as to pass to a room heated to 70 degrees as to an atmosphere of 30 or 35 degrees below zero. We have this up in Canada and heat our houses to 70 degrees when the outside temperature is 30 to 35 degrees below zero. It does not seem to kill anybody up there.

Mr. Jellett:—In answer to that I would say that a man who goes out in a temperature below zero wraps himself up well. Here I am speaking of summer temperature where a man with an alpaca coat steps into a much lower temperature without putting on an overcoat. The conditions are entirely different.

Mr. Payne:—Let him suit his clothing to the variations of the temperature, reversing the process.

Mr. Fish:—I agree with Mr. Jellett. Let the thermometer on the piazza drop five degrees and he will take off the alpaca coat very quickly and put on something quicker.

Mr. Cary:—I think that the whole matter of heating and ventilating here resolves itself into depriving the air of its excessive moisture, and if we do that and have a drop in temperature of four or five degrees, we get the looked for results and that is about all that is needed. But it is quite a difficult problem to take care of the

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moisture in the air and deprive the air of its moisture, and that is the problem which I think we will have to tackle. In these western cities I understand that they do not attempt to cool the air more than ten degrees. The report came from Kansas City that where the temperature inside is only six degrees below the temperature outside, the people come in there and are perfectly satisfied.

Mr. Hoffman:—I perfectly agree with the gentleman who just spoke from an experience that I had in the West 15 or 16 years ago. I was on the plains in the cattle business in southern Kansas. We used to have temperatures there that would run up to 112 and 115 degrees in the shade, and I never felt the heat there anywhere near as badly as I have felt it in New York at 88, and I have always attributed that, since I knew anything about the laws of heating and ventilation, to the relative difference in humidity of different atmospheres; that the whole thing was simply in the humidity of the air. The air out West was almost entirely dried of its moisture and I had no sensation of discomfort at all. I have ridden all day, with the sun shining right on me, after a drove of cattle that was creating a big dust, and I never had any sensation of discomfort so far as the heat was concerned.

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XX.

SCREWED FITTINGS FOR HIGH PRESSURE.

BY HUGH J. BARRON.

(Member of the Society.)

One of the most remarkable things in the development of the use of iron pipe has been the standard fitting and standard thread, both of them depending primarily on the standardizing of wrought iron pipe. When we come to think what the pipe industry would be without these standard articles, we begin to think it marvellous that they have been devised and that an agreement in regard to standardizing was reached so early in the development of the industry. Standard articles of every character tend tremendously to the cheapening of their production and thus fill an economic necessity, but this very advantage has its drawbacks; with standard fittings the great difficulty to-day is that the refining process of cheapening production has gone so far as to call for a reaction in favor of special fittings for special work, and the purpose of this paper is to advocate the manufacture of wrought iron or wrought or cast steel or malleable iron fittings for screwed work for heavy pressures and for all large pipe work except that used for very low pressures. Forged fittings are so much more reliable, so much surer in every way, that it is strange efforts have not been made to displace the cast iron fittings. When the fittings that are now in use were designated, low pressures and small sizes of pipe were the rule. Within a few years the conditions have changed; high pressures are now the rule, and large sizes of pipe in connection with large power plants are no longer the exception. The changes that are required by modern conditions are confined to ells and tees and to sizes larger than three inches; all other fittings, I believe, are safe and satisfactory, and the smaller sizes of tees and ells are not seriously objectionable, even at high pressures, but the ordinary 6-inch ell or tee at 100 pounds pressure is decidedly dangerous, and the engineer who does not feel nervous when he is close to one of these fittings when there is water hammer and heavy pressure combined must be very courageous or very reckless. When the various strains that

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such fittings are subjected to are considered, instead of the usual factor of safety of six being present, there is absolutely no factor of safety at all, or the factor is so slight as not to be worth considering; first there is the pressure, then there is the pressure or tension set up by the taper thread when it is jammed in by the fitter and the chain tongs—this is a constant strain tending to burst the fitting—then there is the shrinkage strain of the casting, slight of course, but must be considered as increasing the complexity of the tension on the fitting. To these add the strains due to the expansion of the pipes and the tremendous strains due to the blow a fitting receives when water jumps into a partial vacuum, and is it any wonder that fittings burst? Blow holes and imperfect castings add to the danger and unreliability of cast fittings; the marvellous thing is that there is not more trouble from this cause, but as pressures continue to go up this trouble will increase. None of the ordinary ells and tees above four inches in size should be used for pressure above 50 pounds. These remarks do not apply to flanged cast fittings, and many get over the difficulty of the screwed cast fittings for power work by specifying and using flanged cast fittings and flanged cast pipe or wrought iron or steel pipe with cast flanges, but I am inclined to think that there is a better way of overcoming the difficulty; that is, either make cast screwed fittings for power work twice as heavy as they are made to-day or substitute forged fittings or cast steel or malleable fittings. I am one of those who do not like flanged joints if they can be avoided, and I believe that, with the proper fittings, screwed joints are far more satisfactory. The question of pipe and fittings for high pressure steam is outside the scope of this paper, but that there is room for improvement in ordinary power piping is evident by even a slight examination of any large plant. Engine builders some years ago, in order to get the initial pressure in their cylinders as close as possible to boiler pressure, advocated long sweep fittings, similar to hydraulic or hot water fittings. Some engine builders made patterns for these fittings that were extra heavy, and I think with a sufficient factor of safety, but I am inclined to believe that a forged wrought iron fitting would be the best, and to have the pipe work almost entirely wrought iron, that is, the fittings and even the valve bodies forged, would be the safest for high pressures. A possible solution of this problem may be in the gradual introduction of malleable steam fittings of heavy pattern for steam work. I have used such fittings for many years and have always found them satisfactory, but the larger sizes are entirely

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too light for present day pressures. If, in addition to the standard flanges which have been adopted by the trade we had a standard ell and tee it might possibly be a step in advance. I am averse to advocating special measures of this kind, as I am afraid they interfere with the natural development of the best device, or have a tendency to do so, but I do not believe any harm can be done by condemning the present cast fitting for high pressure; they have outlived their usefulness and we need a substitute for them.

DISCUSSION.

Mr. Cary:—Mr. Barron seems to lay a good deal of stress on the point that steam pipe ruptures of late are attributable largely to the poorness of the fittings, the lightness of the fittings. I cannot agree with him in every respect. Take the accident that recently occurred on board the St. Paul, and the other accident at Hammerstein's theater—I do not think that wrought iron fittings, cast steel fittings, or anything else would have withstood the rush of water into the vacuum. If you have a large cold steam pipe, open your valves suddenly, and allow the steam to rush into the cold space, a lot of water is immediately produced by condensation, and this is carried on by the velocity of the steam rushing into a chamber of much lower temperature, carrying the slug along until it comes to a change of direction and there it is pretty sure to carry out anything in front of it. The matter of adopting forged fittings is very good if you can get people to pay for it. But I believe I should be ruled out on that, as I said the other day that we should not stand on the cost of work that is done by the members of this society; that we should advocate good work, whatever it cost and try to educate the people up to it. But at the same time I am afraid that forged fittings would be very expensive and almost prohibitory. The matter of casting fittings is now being done by several concerns and they are producing very good fittings, giving much better results than the others and doing away with couplings. I saw a few days ago that a concern in Pennsylvania is rolling up the ends of the pipes in a manner somewhat similar to expanding; they swell the pipe up and roll it right there and make a flat flange. It is done in Pennsylvania. I am sorry that I cannot give the name of the concern. It is represented by Mr. Charles A. Hagne.

The President:—It is Best, Fox & Co.

Mr. Cary:—That is the name. The more we can do away with fittings and produce pipes with the ends brought up this way into a flange the better we will be off. I think that is a step in the right

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direction. I understand that they are turning out pipe flanges from three inches in diameter upward. They are doing also a great deal of bent pipe work, and that I believe should be distributed more liberally in steam piping, to allow for expansion and contraction to be taken up on large liberal bends. By the use of this I think we will do away with a good many of the troubles that we have with the fittings to which Mr. Barron refers.

The President:—Allow me to introduce Mr. William Kent to the society.

Mr. William Kent:—I am not a member of the society but I have taken a very great interest in this subject of cast iron elbows from the fact that I had occasion to investigate the accident on the St. Paul—not officially, but unofficially, and the accident at the Edison building. In the St. Paul there were nine men killed, and the Hammerstein accident followed. After watching the newspapers I see that steam pipe explosions happen all over the country, and they are always, I believe, not pipes but fittings. I hope that nothing that Mr. Cary has said will lead anybody to think that cast iron is not so dangerous. We do not know that the cause of these explosions was water hammer. Certainly the expansion is the possible cause of nearly all these accidents we have had. In the case of the St. Paul it is more than probable that expansion had something to do with it, and possibly the two causes together, both water hammer and expansion. But I hope the alarm will be sounded all over the country that cast iron elbows are very dangerous. If you consider what expansion does in a system provided with cast iron elbows, you have something acting at a great leverage. Cast iron is not meant to bend, but steel forgings will. Steel castings, as compared with cast iron, do cost a very large amount per pound; still it is a very small fraction of the total cost of the steam pipe, and therefore every inducement should be made to put in cast steel elbows.

Mr. Cary:—I seem to have been somewhat misunderstood. I thoroughly agree with Mr. Barron and with what Mr. Kent has just said, but I merely wish to say that it was not always on account of the fittings that these accidents took place. I named a few exceptions and I only meant to put them forward as exceptions. But I think that Mr. Kent has voiced my sentiments in this matter thoroughly and I agree with him and with Mr. Barron.

Mr. Fish:—I think cast iron fittings have been very successful, and there have been comparatively few accidents due to their breaking, considering the larger use of them now. I remember twenty years ago that malleable iron fittings were quite extensively used

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in steam heating practice, the original intention being, I believe, to make malleable iron fittings for water and gas fitting purposes only. It was stated by steam fitters at that time that in using malleable iron fittings on pipe the fittings stretched, and did not make good, serviceable, or tight joints, but, unlike cast iron fittings, were free from breakage and from unequal expansion and contraction. Still, I think at present, where engineers are doing high pressure work, heavy cast iron fittings are made for this purpose and can be supplied. I cite a case in point; the makers of the Baker car heater use extra heavy fittings in connection with the erection of their heaters. I think the engineer in designing work, and especially where extreme pressures are to be carried, must provide and use extra heavy pipe and fittings.

Prof. Carpenter:—My experience in the way of pipe fitting the last two or three years has been, I think, more in the line of this sort of work than in the line of lighter work, and I have found that the problem is a very serious one and that it is very difficult indeed to get a pipe that will stand high pressure steam put up properly. We are likely to be troubled with leaks and we are also likely to be troubled with the bad effects of expansion, and then in addition come these dangers that have been alluded to. I have found out from my own practical experience that where the pipe work is of rather small size, say under six inches, which I would call small size for pipe work, that the extra heavy cast iron fitting is fairly safe, used with an ordinary pipe. There is no joint in the world that will stand the strains that this high pressure piping is subjected to if the expansion is not properly taken care of. I have found that what we call the ordinary spring joint will take care of this expansion up to 100 feet. I do not like to use slip joints in this kind of work, because I have known of accidents and came myself near having a serious accident with a joint of that character. And while I have used such joints, I think I never will do so again. There are certain accidents which pertain to the class of slip joints which make them, I think, unreliable for this work. But in this class of work, where we go to pipe sizes larger than six inches, I think it unsafe to use cast iron in any form whatever. In that class of work we can usually afford to pay every cent that will be charged for the higher grade of work. We can use bent pipe and we can use steel flanges. They are now making steel roll flanges and we can use where necessary cast steel fittings. Those can now be had. They cost more, but the character of the work really demands it, because the extra cost of the fittings to the work is a very small matter compared with the cost of the en-

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gine. I have also in some recent work been very careful to put up duplicate pipe lines throughout. That may seem like an unnecessary precaution; but generally in the plants in which this work goes, a stop-down means more expense than two or three lines of pipe, and for that reason I believe it would pay in the way of insurance to have these two lines. Usually the two lines will not cost much more than the one line provided we design them on the principle that we will use the areas of both lines constantly, expecting to shut off one line and run at a very much higher velocity in case of any break down or accident. That is, it is expected to only cover an emergency. Our usual proportion of pipe lines is 50 feet per second of the steam. In my power plant we have proportioned the pipe for 100 feet per second, all of which, if we were obliged to carry our plant through one of these pipe lines for a short time, we could do it without having to shut down.

Then there is one other point I have found in which my experience has not agreed with the experience of some of the members. For the smaller sizes of pipe lines—and I would put six inches as the largest of the smaller size—I have had better success with screwed joints than with flanged joints. In fact I have had no end of trouble with flanged joints, even made metal to metal, ground and put in all sorts of ways, whereas I have had no trouble whatever with screwed joints. A flanged joint is a very expensive joint to make, if it is made well. For this class of work it must be made in the most expensive way; your lines must be perfectly aligned and the joints must be brought together. We must have metal to metal to get the best work. When packing is used of any kind it is liable to make trouble—pretty certain to make trouble; so I have preferred, as far as possible, the use of screwed joints in the smaller pipe lines. In the larger ones, of course, flanges must be added, and the larger pipes are generally lined better, and we have had less trouble from flanged joints in the larger pipes than in the smaller ones. Some of the lines we have put up have run as high as sixteen inches.

There is one thing that makes a cast iron fitting more desirable in heating work than all others, and that is the fact that it resists rust and corrosion somewhat better than these other fittings, and in steam heating work that is the principal cause of deterioration. Of course you get very poor fittings occasionally; they are thin on one sde, but that might happen with any of these kinds of fittings and they would rust out just simply that much quicker. So that what I have said with reference to the other class of fittings for power work does not apply to this other class of work. Then I think

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there is one other difficulty that stands in the way of getting good pipe work in power plants, and that is the fact that the workmen you can hire are not accustomed to that class of work. They have not had the necessary training, and actually in two plants that have been under my supervision for the last year the first piping had every bit of it to come down and be put up over again, because the workmen were careless; they did not understand the necessities of the case. That is a matter of difficulty which will be remedied after the men have had more experience.

Mr. Andrus:—In the locomotive shops at Paterson all of the fittings used on the locomotives are very heavy malleable iron. I suppose, on account of the strain and jar, they have found them more serviceable than cast iron.

Mr. Fish:—I might say for the information of members that at the recent exhibition in Boston I saw some beautiful specimens of long turn elbows of wrought iron pipe with flanges, made by the Walworth Manufacturing Company, which showed that when it was necessary to make a right angle turn it is not necessary to use a cast iron fitting for that purpose.

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XXI.

FOOD FOR THOUGHT.

BY WILLIAM H. MCKEEVER, NEW YORK,

(Junior member of the Society.)

You will pardon me for intruding on the valuable time of this convention by these remarks. I had intended to attend here as one of an audience and to take no part in any discussions. So far I have succeeded very well, but the feeling of the inner man has overcome my good resolutions and hence this effort.

It is not my wish to be considered in the light that any criticisms which may be manifest in my remarks are personal, but only for the well-being of the society, whose interests I have at heart.

The emanation of my remarks was caused by an utterance made by a fellow-member during the discussion of one of the papers, in which he stated that we were here to deal with facts, not theories, a remark from which I must take exception. As the objects of this society present themselves to me, facts are, measurably speaking, secondary. I am a theorist and believe in its development, for we have to assume in order to make deductions in order to form.

We snould be here, firstly, to deal with new ideas and new theories, as the time allotted between our meetings is ample for solving the problems presented by such new theories or ideas. Looking at the presentation of facts, we have only, in order to keep posted on such current events, to subscribe to and read such papers as those whose efforts are in our direction. What matters it to us whether a tee is left looking up or down or out, or whether the system is single pipe or double pipe or multi-pipe? These things only resolve themselves into a question of condition and circumstance and are of too little detail to take up the time of the convention. As engineers, we will differ and hold to our own conclusions in spite of all arguments to the contrary. At the present status of the game we are all at sea, no definite standards being adopted in any application.

I might recall to you the statement made by a prominent engineer at our last annual meeting regarding the difference of the heating surface specified by two of our most prominent firms in

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the country in the contracting business—a difference, if I recall rightly, of about 100 degrees. Now what we should seek, and, as I believe, that is our ultimate end, is to standardize the conditions. Let us all descend or ascend to a common plane. I do not advocate any hurry in this direction, and I think that the facts, or, better expressed, the standard we adopt should be expressed in such form as to prevent the ordinary from interpreting.

To my mind nothing is so dangerous to the well-being of our society as the promulgation of our ideas broadcast. Let us guard our interests selfishly, and let those who choose to stay on the outside seek elsewhere for their knowledge. Let us seek to elevate our membership by increasing the requirement, or, better expressed, by the higher education of our coming heating and ventilating engineers. As one of our previous speakers has said in his remarks, the tendency of the time is to complication. I must say that I rejoice in the fact, as complications elevate our plane and bring us above the simple application of the rule of three.

The simple matter of house heating, as ordinarily done, does not, in my opinion, give us the license to call our profession a science. Where our engineering should come in is in the reversion of the natural laws, of which a friend recently spoke; we do not want to trust to nature for our results; we want to obtain effects by the application of our engineering knowledge, because in the application for results from nature we must be subservient to nature where we ought to command.

Now, to conclude my remarks, I would suggest that it might be a good idea if our council would, in sending out notice for our next annual meeting, devise some plan for the presentation of something new or original in the papers presented, boiled down to its smallest compass. The whole matter is simply this: Our present convention has been more on the personal experience of its members than for an interchange of ideas or the spreading of new theories. Do not let us fall into the rut that we have reached the highest pinnacle of our profession and that each of us in his own opinion is perfect and that there is no room for improvement. Let us seek to develop the genius that somewhere lies dormant and elevate ourselves and our profession, so that we become as necessary to mankind and its comforts as the physician is to the sick person.

DISCUSSION.

Mr. Hoffman:—I think one little remark that our friend made might be enlarged upon, and that is the promiscuous publication of the discussions on papers that are read in the meetings. That

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might be a very good thing for the general public, but looking at it from the selfish standpoint of the interests of this society, is it not rather a detriment than an aid to us? The reason I speak that way is because I was soliciting a young friend of my acquaintance to join the society. I told him I thought it would be a benefit to him. He is a very young man and has very good ideas, and I thought that his joining the society would be of mutual interest.

He said, "What use is it to me to join the society? I can read all the goings on. I can take the papers up to my room and I can read everything that is said and done there and I haven't wasted any time and I get all the benefit that you get from going to the meetings." It seems to me that the remark of our friend is applicable to cases of this kind. If we did not publish promiscuously the papers and the discussions, such men as my friend, who would be an addition to the society, would naturally have to come into it in order to gain the knowledge.

Mr. Cary:—I am afraid that I cannot agree with the gentleman who has just spoken. The object of the society is to investigate matters relating to heating and ventilation. It is not a society for our own good, a mutual admiration society, or anything of that kind. We are not only trying to elevate ourselves, but we are trying to elevate the public in general. The more that we can bring our ideas forward and publish them broadcast the nearer we will attain the results that we have started in for. I believe that all that is done and said here should be published as broadly as possible and let these people read them outside if they do not care to come into the society. There are plenty of others that do and who can see the benefits of belonging to the society. I believe that the house of the American Society of Mechanical Engineers is open. There is a large library that is open to the public. People can come in here and educate themselves and learn from what we have done and from what we have got here. The object of that society is to raise the plane of mechanical engineering in this country. I say that, being a member of the Mechanical Engineers, and I think that the Heating and Ventilating Engineers should place themselves on the same plane, and I believe that the other engineering societies also look at the matter in the same light. I do not think we can do any better than follow their example.

Mr. Jellett:—I must say that I agree with Mr. Cary thoroughly. I believe, as I said in the address at the opening of this convention, that the widest publicity of the doings of this society is to the interests of the society itself. I believe that as the general public get to know of the improved methods of heating and ventilation

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there will come a want and there will come a demand for the heating and ventilating engineer which does not now exist. We know that a large proportion of the work done in this country to-day is done without any careful consideration whatever, simply because the public is ignorant of the fact that there is necessity for such careful planning and consideration. When they come to know that it is a desirable thing; that there is something more than paying for the apparatus; that its design, arrangement, and maintenance are all to be carefully considered just so soon there will be an increased demand for the engineer. I believe there is only one way to get this desirable result—not to keep it to ourselves and to keep the public in absolute ignorance of what we know, but to give them the benefit of our experience and tell them what they should know and what it is to their interest to know.

Mr. Gormly:—I should be very sorry to see our society go back to the practices of past ages when men endeavored to hide any little matter of knowledge that they had for fear that their neighbor would also get some benefit from it. I think it would be a mistake for our society to do anything of the kind, and I also think that the publication of the matters that are transacted in our society is a benefit to us and not an injury. I would be very sorry to see this idea prevail, that we should keep our knowledge to ourselves.

The President:—I think that the history of the past has proved that the societies have not hid their light under a bushel.

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XXII.

TOPICAL DISCUSSIONS.

SECOND ANNUAL MEETING.

Topic No. 1.

Judging from the present standards, what is the ideal system of heating for moderate sized dwellings, taking into consideration satisfactory results in warming, economy in operation, ease of management, reliability under all conditions, and original cost of installation?

Mr. J. J. Blackmore:—To start this discussion it seems to me we should try to get at what are present standards. I confess I have always found that a difficulty. I would like to hear a little discussion from the members as to what they consider the present standards are.

Mr. Quay:—I think the gentleman has given us a question pretty hard to answer. I am afraid we have not any present standards that could be laid down as standards. There may be a certain standard for hot water heating and a certain standard for furnace heating, but the question is proper as a starting point, to know what our platform is. If any one can answer I should like to hear.

Mr. Cary:—I think that we have rather anticipated this in discussing Mr. Kramer's paper. As this is put down I think it is merely intended to open the way for a discussion as to the efficiency of the different systems for dwellings of the size mentioned. We have already started on that line, and I do not see why a continuation of what has gone before would not touch on this first topical question.

Mr. Gormly:—I take it that the present standards as they are mentioned here mean the average practice or the ordinary practice of heating buildings with hot air or by steam or by water. Possibly there is quite a variation in the practice of different firms and different individuals in this matter. As a part of this topic relates to the question of economy in such apparatus I would like to state

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what my experience has been with two buildings that were erected at the same time. These two buildings are dwelling houses, of stone, built just alike, and built at the same time and standing not 25 feet apart. Each of them is exposed, standing in an open lawn. One party put water in his house and the other party put hot air in the other house. There was something of a contention between the two owners at the time as to who should have the warmest house and the best ventilated house when the plants were put in operation. They have now been in operation three years, this being the third winter. It was found that the house using hot water, although it had, in part, an indirect system of heating and in part a direct system was heated with eight tons of coal, whereas the other house burned twenty-seven tons of coal; the only difference in them, so far as could be noticed, was that one was heated by a hot air furnace and the other was heated by water. I think this has a direct bearing on this topic, as a branch of it seems to be "economy in operation." I cite this as one instance where I had an opportunity to test the difference between two systems, one of hot air and the other of water, in houses built just alike, occupied as private dwellings and exposed necessarily alike; and there has been a difference ever since the start, one party using eight tons of coal to heat the house and heat it well, and the other party heating the other house equally well, but using twenty-seven tons.

Mr. Cary:—The gentleman has been very cautious in not stating which uses the twenty-seven tons and which uses the eight tons.

Mr. Gormly:—The water heating apparatus is using the eight tons and the hot air furnace is using the twenty-seven tons.

Mr. Hugh J. Barron:—I think Mr. Gormly has the right conception of what this topic is. I think if gentlemen would state what they consider an ideal system for a moderate sized dwelling, say costing not over $10,000 and not over four stories in height, and 25 by 60 or 40 by 40 feet, which is the ordinary average American house, it would start an interesting discussion. My own conception is that the hot water system is the ideal system for such a house, half indirect and half direct; that system will give more satisfaction and will be more economical than any other system in the world which has yet been designed.

Mr. Payne:—I certainly agree with the previous speaker that the ideal system is half direct and half indirect hot water. I think a house needs direct radiation for the comfort of occupants. I have just moved from a house heated by direct steam into a house heated with hot water. The average temperature of both was all right. But I noticed especially that my children feel the difference.

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They miss the direct radiating heat on the body, and I think if we combine the two we get both the pure air and the benefit of the direct heat on the body. And then we all know the advantages of hot water in the various climatic changes which we experience in this part of the country. We can accommodate it to the various changes and not overheat the house at any time, if the system is handled in an intelligent manner.

Mr. Quay:—I consider that the best and most economical heating of a house is with steam at or below atmospheric pressure. Of course there are different things to be considered—economy and efficiency and convenience and comfort. It is not the economy alone. Of course, a great many think that the only proper way of heating, in order to get convenience and comfort, is with hot water. It is a fact, however, that you can heat with steam at a sufficient amount below atmospheric pressure and you get practically the same temperature as you do with hot water, thereby getting the same comfort. It is also as economical, if not more so, as hot water heating. It is more easily controlled. But there is another thing; it is not the system of heating altogether that we have to consider; if we are going to heat with a furnace or hot water or steam, especially with hot water or steam, the construction of the boiler has a great deal to do with the economy. It is hard to tell how many different boilers are made in this country. Nearly every stove manufacturer makes a boiler, and very few of these house heating boilers are constructed properly. They are not rated properly, nor constructed so as to be economical. I think that we have to consider the question of heating with low temperature; that is, generating steam at low temperature, and also of heating with a low combustion, so that the gases go into the chimney at a very low temperature. These are matters that we must consider just the same as high temperature electric heating, and we may as well get down to business and look at these facts. The fact, too, has been demonstrated that you can generate steam economically with a very small amount of water, having a thin sheet of water and a large fire surface exposed to a low combustion fire. I do not believe that house heating boiler men have considered this as they should. If they had, we would not find the kind of house heating boilers on the market to-day which we do find. A great many of them are not constructed at all on economical principles. Another thing is rapid circulation. Now the point has been brought out that the advantage of a furnace is that you get the heat directly from the coal in the shortest way, but a difficulty in hot air heating is the distri-

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bution of the heat. The construction of the heating system also has just as much to do with it as the boiler. The only reason that we have not more satisfactory results from steam and hot water heating is because they are not properly constructed. The size of the pipes and the amount and location of the radiation, pitch and grade of the pipes have not been considered nearly as much as they should have been, and it is merely because the price has not been paid. People are not willing to pay the price and the contractors have not the courage to ask it. Another reason is that some people do not know how to construct a job of that kind. I think it is just as necessary to have an engineer lay out a house heating job as to lay out any other kind of a job. The trouble with a great deal of house heating is that an engineer is not employed; that they heat the building without any plan. There is not enough attention given to the engineering feature of house heating. I think that we should consider that feature of the case as engineers. The question of house heating should be taken up from the engineer's standpoint.

Mr. Cary:—I should like to refer to a few points brought up by the gentleman who has just spoken. He speaks of having a little water in a steam or hot water heating plant. When you have very little water you have very little body of heat. It is hardly a safe practice to go ahead with a boiler that has very little water capacity. You want a sufficient amount of water there to hold your temperature up within reasonable limits, as when the fire dies out, with but very little water in the boiler, your steam will go down very rapidly. You want to have enough water in your boiler to hold the temperature, the pressure, fairly constant.

As to the matter of selecting boilers for different houses, I think that a man, besides being merely an engineer, should be somewhat a judge of human nature. I think it would be well to see who is is going to take charge of the plant. You put in a simple hot air furnace—there is nothing simpler than that. The girl in the house can take care of it. There is very little complication in it. If it gets filled up with ashes, they have got to stop and clean it out. But as you get to work with more refined apparatus, there is more complication, and the person who is to take charge of the plant is certainly a very big factor in its successful operation. I think that is as much a matter to be considered as the plant itself. I know of a plant up town in a house which has been put up by a gentleman in Seventy-third street, in which a great many refinements and new ideas are embodied. The plant has worked there successfully and burns very little coal. The owner of the house

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has a yacht on which he spends a great deal of time in the summer, and in the winter he takes the engineer off the yacht and puts him in charge of his house plant. In consequence he gets splendid results. Heating a house and keeping the temperature of the steam below 212 degrees necessitates the use of a vacuum system, of course. As you decrease your pressure the boiling point goes down. But that of course complicates matters and it will require more attention to keep your plant in successful operation; it will require better service. I think that is as much a matter to look into, to see who is going to take charge of the plant and then we can decide on the best method of heating. It may be that some of the servants are to be in charge of the plant who know nothing about a furnace. You want to put in the simplest furnace you can get, in such a case, and you will get the best results. If you are going into more refinements you will have trouble.

XXII.—Topic No. 2.

What is the best method of ventilation for office buildings and those having comparatively few occupants?

Mr. Jellett:—Mr. President, I do not know that I am particularly posted on this matter, but I am willing to open this discussion. The modern office building, I take it, as constructed to-day, is a building that has not wall space enough left to put a flue in. We have a skeleton steel building, but the pier space between the windows is cut down to the narrowest possible limit in order to get the maximum amount of light. Therefore, the question of constructing the flues in the outer walls is practically prohibitory. Again comes the question of the subdivision of offices, and in a fireproof structure this is usually made up of a fireproof material, and of a thickness which does not admit of flues,—namely, malachite, hollow bricks, terra cotta lumber, or some such material, two, three, or four inches in thickness. Again, the steel web fastening the building together does not permit a continuous flue passage. Therefore, some method of ventilation must be devised that will connect with the various rooms and from the various offices to an air shaft or exhaust chamber, something that can be erected without interfering with the material strength of the building, or interfering with its proper light or use. This question is one that is not yet solved and has only recently been attempted, so far as I know. There may be men here who can give us the information that most of us lack. The heating of such a building is narrowed down practically to direct radiation and direct-indirect radiation. I had charge of one building where we have a system of direct-indirect

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radiation, building ducts through the outer wall, putting a screen on the face and taking in our air supply in this way; then placing registers on the opposite end of the room, putting a false ceiling below the girder and using the space between the false ceiling and the ceiling proper as the duct, carrying this horizontally on each floor of the building to a central aspirating shaft. This has been done with fair success. But you meet there with difficulties of construction in carrying the horizontal ducts on each floor. The false space must be made sufficient to allow the intersecting beams to pass through it, and there must be sufficient height and area to allow this. Otherwise the air currents are checked at the various points by the intersecting beams. The method of carrying up vertical air shafts through such a building and connecting directly with them is probably superior to that which I have described, but it is a very difficult thing to get in the average office building. The owner who puts up such a building figures on the return of so much money per square foot per annum, and if he takes up sixteen square feet for an air shaft, that means the loss of so many dollars per square foot, and he is figuring on returns, not on results in ventilation. But the matter of constructing a false ceiling and leading the ducts to the central aspirating shaft can be done for less money as being part of the structural work. These hollow spaces need not be finished. On the end of the main aspirating shaft there should be a fan. A fan will give much better service under such conditions than an aspirating coil, because there are so many feet of horizontal flues with a great deal of resistance, and these are duplicated on every floor of the building. If you take a twelve or fourteen story building you will find that the amount of friction is very considerable and practically prohibits the use of an aspirating coil. The best method would be to use an exhaust fan, applying a motor and putting it up in such a way as to cause the least vibration to the building. I have in mind a building which is heated by direct-indirect radiation, the radiators being concealed under the windows, which are recessed with screens across the pane. The air is taken in under the windows. The rooms are ventilated from the opposite side. The building is six stories high. The three lower stories are carried directly to the basement. The three upper stories lead to the left and are connected by galvanized ducts to the main aspirating shaft, this flue leading to the fan, half of the building dropping to the basement, the other half leading to the loft. The fan discharges entirely through a main air shaft leading to the roof of the building. By actual anemometer measurements at the registers the guarantee was to be 45,000 cubic

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feet of air per minute, and it varied on the test from 42,000 to 51,000; this variation in quantity was due almost entirely to the variations in the outside weather conditions. The fan is of the disk pattern and the resistance against it was so very considerable that on a warm day we found that the fan delivered above the results required; that on a cold, sharp day it delivered below the results required, showing the different effects of moving the added weight of air by means of the fan, the speed being fixed. I would like to hear from other members of methods of this kind, because this is a comparatively new system. It has not yet in my judgment been worked out in any satisfactory way.

The Chair requested Mr. Andrew Milligan of Buffalo to address the meeting.

Mr. Milligan:—Mr. President, I do not know that I have had very much experience in this line, but I might say that we are now going through the mill with one building. The building is not completed yet. It is the Real Estate Exchange Building of Buffalo, designed by Green & Wicks. It is an office building, containing ten office floors and basement offices, with a frontage of 180 feet on the street and 80 feet in depth. The contents of the entire building are 1,250,000 cubic feet. The specifications require an entire change of air in all the offices on an average of once every fifteen minutes. None of the offices, with the exception of two, which cannot be reached conveniently by hot air ducts, are heated with direct radiators. The building is heated by two separate apparatus, one for the north side and one for the south side, the two apparatus having no connection one with the other. The air for each apparatus is drawn down from the roof over the exchange room, which is on the ground floor. In these inlet flues is located the filtering and air washing apparatus. From these the air passes through two blast fans (size 150-inch housings) then through the heater coils in two coils of an aggregate of 22,000 lineal feet of one-inch steel pipe. From the coils the air passes through vertical flues to the several office floors and thence is distributed to the offices above a suspended ceiling in the corridors, the inlet registers in the offices being located on the inner wall of the offices over the corridor doors. The outlet registers for the vitiated air from offices are located in the corridor walls, with the register in the office in the base board, and the register in the hall some two to three feet above the one in the office. Thence the air passes through the corridors and up through the elevator shafts, four in number, all working in the one open shaft, the upper part of the elevator shafts having eight 36-inch Globe ventilators on the

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roof. Vertical flues for conveying the air from the basement to the various office floors are located on the interior of the building on the inside angle of the corridors in a space which is least desirable for office room and each apparatus has an independent flue directly from the coil to each floor. The vertical flues are so located that the horizontal runs in the several corridors do not exceed 25 feet in length to the furthest office. Each and every office in the building is controlled automatically by a pneumatic thermostat.

Mr. Stangland:—I would like to ask Mr. Milligan if he uses any direct radiation.

Mr. Milligan:—Not in offices. We have used direct radiation in the elevators in order to avoid connecting the elevators with the same flues that run to the offices. I think there is only a total of about one thousand feet of radiation in the whole building.

Mr. Stangland:—Do you use any method of ventilating the toilets other than the plenum system?

Mr. Milligan:—No, sir. We have a large vertical shaft running behind the line of closet rooms. We use no extraction fans whatever—simply get the ventilation by heating the air.

Mr. Stangland:—The building is not finished yet?

Mr. Milligan:—The building is simply being plastered now. Before I left home the steam was on one coil only, so we have had no results yet.

Mr. Stangland:—The toilets in the higher floors will free themselves as well as the lower ones under those conditions? You have no means of ascertaining that I suppose?

Mr. Milligan:—No, sir.

Mr. Stangland:—It is my opinion that without some other means of extracting the air from the air shafts from the toilets than with the steam pipe running up and down in the flue, the rarification of the air, if special attention is not paid to a special clearance at the top, will make the flue empty itself into the closets on the upper floors.

Mr. Wolfe:—I think that is almost always regulated simply by what we call a sleeve underneath, so that each room will have its proper proportion of draft in the chimney.

Mr. Milligan:—In addition to the inlet draft of the ventilating flue itself, in a building into which they are blowing so much air, we have the addition of the forced air coming into the building finding its way into these elevators from the halls.

Mr. Jellett:—I would like to ask at what velocity the air enters those offices. Mr. Milligan speaks of the distance between the cor-

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ridor and the outer wall being some twenty-five feet, the inlet register being located near the ceiling. At what velocity does the air enter the room? If the air does not come in at a good strong velocity, taking the average amount of glass surface, it would be very difficult, I should think, to warm the room close to the outer wall unless the pressure was quite excessive.

Mr. Milligan:—I cannot tell you what it did. I can tell you what it is expected to do. The velocities were specified not to exceed 1200 feet, I think, through the vertical shaft; through the horizontal ducts not to exceed 800 feet; through the register connection branches not to exceed 500 feet; and through the registers not to exceed 400 feet.

Mr. Jellett:—I have had some experience in moving air horizontally with such velocities and I have not been able to heat as far as 25 feet from the point of inlet under those conditions. If the outgoing flues were on the opposite side of the room from the inlet I could understand its making a complete circulation. I have in mind now a building where the flues are carried horizontally along the corridors, blowing into the offices, where they are carrying a much higher velocity than that, and on their outer rooms they have not any unusual exposure. They have never been able to warm the rooms to anything like the point agreed on within a distance of six or seven feet of the outer wall even though increasing the speed of the fan. The temperature of the air is all right, but it is due entirely to the velocity. The outgoing flues take the air and carry it away and the room is comfortable within a radius of fifteen or sixteen feet of the register, but the outer portions of the room are not comfortable and never have been.

Mr. Wolfe:—I should say in regard to Mr. Jellett's criticism that I do not think the velocity has much to do with it. I do not mean that exactly, but I mean to say this—that the primary effect on the corner room is probably due to the window surface and possibly the bad fittings of the window frames and the joints, etc. But the principal fault in my mind would be that there is not enough air coming in, regardless of the velocity. We know that at a velocity of 100, if the room is well built (I do not care if it is 40 feet from the window), if we admit it at a velocity of 100 and the room is reasonably tight, that air, simply from gravity, will find a level on the ceiling, about the same as water would find its level on the floor from the same cause. Now what will counteract that will be your poorly constructed buildings or your insufficient air supply, and your insufficient air supply would be accounted for by the leakage through the windows, etc., enough to fill your ventilat-

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ing shafts and so counteract the flow of warm air to the outlet. I should think that 400 feet velocity was quite sufficient, if not more than you really need, because if you get enough warm air in, in either way the natural gravity plan will work the rest.

Mr. Jellett:—I cannot say that I agree entirely with Mr. Wolfe. As I understand this particular system there is an outlet flue on the same wall as the inlet flue. As I understood the sketch, there is an outlet register at the floor of the same room, leading directly into the hall. The hall is ventilated by a shaft in which the rapidly moving elevators are causing a suction.

Mr. Wolfe:—I did not so understand it. I understood that he conducted it through a separate flue.

Mr. Jellett:—The halls of the building become the outgoing flue, the elevators forming the motive power to suck the air; then there is a series of ventilators on the top to emit the air. That being the case you have an in-supply and an out-supply directly under it.

Mr. Wolfe:—I did not understand that. I will take that back.

Mr. Jellett:—I was speaking of this particular condition where the outgoing flue was on the same wall as the inlet flue.

Mr. Wolfe:—It is a very grave question whether it is an outlet flue or an inlet flue. There is no positive outlet, under the arrangement, of ventilating the elevator shaft. It is not an outlet under certain conditions of temperature; but if he had an exhaust fan, why then it would be all right.

Mr. Milligan:—I might say that every room is controlled with a heat regulating apparatus, and in severe cold weather the air supply to one side of the building is cut off, so as to accumulate the geater part of the air in the ducts leading toward the cooler side of the house. We have expected to counteract some of the influences of the outside winds by such apparatus.

XXII.—Topic No. 3.

What are the relative merits of the overhead system, the usual 2-pipe method, and the single pipe main with 2-pipe risers in hot water heating?

Mr. John A. Fish:—If I understand this question right, I would say that both systems are of equal value, so far as my experience has gone, if they are properly applied. In my own house I have a hot water apparatus constructed on the 1-pipe principle or circuit system which is doing very excellent work and is entirely satisfactory. The apparatus in our company's office is constructed on the 2-pipe system, so called, and it is also efficient and satisfac-

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tory. There are many buildings in which a hot water apparatus can be constructed on the circuit or 1-pipe system and considerable expense saved to the fitter both in material and in labor, and when intelligently constructed will give the best results. I do not observe any difference in the temperature between the radiators connected on the 1-pipe or circuit system, reasonably close to the boiler, say two or four feet away, and those 25 or 30 feet away, although there is unquestionably some difference, enough to cause circulation. The 1-pipe or circuit system can be applied with perfect success and as good results obtained as with the 2-pipe work. In some buildings, however, the 2-pipe system is preferable. Both are without doubt good and if placed with judgment and intelligence will give equally good results as far as my experience has gone.

Mr. Dean:—I wish to mention a system which I examined some time ago in the First National Bank Building at Terra Haute, Ind. One of the local fitters asked me to go and look it over with him. I found the temperature of the water at the boiler 120 degrees. A 5-inch main led into the building, making a complete circuit and back to the boiler same size. The boiler was in a boiler house about fifteen feet back of the main building; the pipes went in under ground, the supply openings for the radiators being taken out of the top of the main and carried back into the main at the bottom. There were 476 square feet, I think, of direct radiation connected. The temperature of the first radiator seemed to me as hot as the pipes where the water left the boiler. The building, I might mention, was just then being plastered and was very cold. Half way around the building you could notice a very perceptible difference in the temperature of the water, and at the last radiator, just before the main returned to the boiler house, you could scarcely discover any heat by putting your hand on the pipe. I was there again about two months later. The outside temperature was perhaps 20 degrees below zero. The job had been completed. I say completed—they had a fan system with indirects that was not running either time that I was there. The last time I was there the temperature at the boiler was exactly 200 degrees, and again I could notice no difference between the temperature of the water at the boiler and at the first radiator and very little half way around the system. At the last radiator on the system before the water returned to the boiler room there was perhaps a difference of 30 degrees between it and the temperature of the water where it entered the building. This difference of temperature I am guessing at. There was a thermometer on the building at the outlet, but none on the return pipe. The job was done by some Chicago firm. It was a closed tank system.

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The main runs down hill from the boiler around back to the boiler or very near to the boiler.

Mr. Fish:—I would say, Mr. President, there is nothing new about the 1-pipe system of water heating. If we refer to the examples given by "Hood," we will find this system very fully explained. In the year 1882, after reading his work and rather doubting the correctness of his theory on the 1-pipe system, I set up an experimental apparatus. I ran a 2-inch main pipe from the boiler, making a continuous circuit, connecting six box coils containing 60 square feet of radiating surface each. The circuit was about 80 feet in length, and when the apparatus had been working two hours the thermometer on the boiler and that in the return pipe did not vary five degrees in temperature. Taking my own house as an example, which is of the ordinary cottage type in the country, I set up a 1-pipe system of hot water heating to demonstrate its efficiency and establish confidence in the system among some of my friends, who were skeptical about its working and prophesied failure. I set a hot water heater having a 22-inch grate and connected it with a 2-inch main, making a complete circuit around my cellar—some 63 feet. The main circuit pipe is carried around the cellar perfectly level until within ten feet of reaching the heater, when it descends or pitches toward the heater. The radiators are taken off the main pipe bv placing a flow tee with outlet looking up, while the return tee is looking sideways. I would advise, in putting up these systems, getting the main or circuit pipe in the basement as close to the radiators as possible. My main supply pipe is two inches in diameter and I have upon it 380 square feet of radiation, in addition to a circulation of 100 lineal feet of 1¼-inch pipe. I have reached the conclusion from practice that the following sizes of pipe may be safely used to carry the amount of radiation on a 1-pipe system of water heating. A 2-inch main pipe will supply 400 feet of direct radiation; a 2½-inch pipe, 600 to 700 feet; a 3-inch pipe from 900 to 1,000 feet, and a 4-inch pipe from 1,500 to 2,000 feet. I would state that I have connected to a 4-inch main pipe 2,000 feet of water radiation and it has successfully carried it. These sizes of pipe are simply given as my opinion and based upon some experience. I can vouch for the 2-inch and 4-inch pipe.

Mr. Wilson:—In respect to the 1-pipe system I have found, in the majority of instances, that this system is installed in very small work. I know of but one exception to that, and that job I did not see. It was a job done by McGinnis Smith & Co., of Pittsburg. I cannot see that there is anything gained by the use of a 1-pipe system. I do not think it is as near positive. I cannot really believe that it would be beneficial in a large installation.

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Mr. Fish:—I might say for the information of Mr. Wilson that in the Pillsbury Hospital, built a few years ago at Concord, N. H., the water heating apparatus was planned and installed by an engineer from St. Paul. It was erected upon the 1-pipe or circuit system. A 4-inch main pipe was used, and the construction of the apparatus on this plan was looked upon at that time with doubt by local fitters. After completion it was very closely observed in its operation, and I personally examined the system and with some others reached the conclusion that the apparatus was a success and that we had learned something. The apparatus has been working about six years and has been very satisfactory. The indirect heating used in this building was on a separate circuit main pipe.

Mr. Dean:—I want to correct myself in what I said a little while ago. In the 1-pipe system of which I spoke the returns were brought into the side of the bottom of the main by eccentric T's. I also wish to ask Mr. Fish if he has in his experience had the same result on a low fire that he did in the instance referred to; the first radiator being fairly warm and some of the further ones being cooler?

Mr. Fish:—With reference to my own house I must answer no; I did not. Of course, when the fire is low the radiator at the extreme end of the system is not as warm as the first radiator on the line. That is equally true with the 2-pipe system. When the apparatus is working and the temperature of the water stands at the boiler about 170 degrees, you cannot notice any particular difference in temperature in the radiators. There must, however, be some difference in order to cause circulation, but the difference in temperature is not any more perceptible than that experienced on a 2-pipe job.

Mr. Dean:—Your main rose from the boiler to the last radiator?

Mr. Fish:—No; the main pipe was carried level, with the exception of the last ten feet, when it was pitched toward the heater for the purpose of draining.

Mr. Payne:—As the discussion is drifting to examples of the various methods of doing this class of work rather than a discussion of the merits of the various systems mentioned in the question, perhaps I will be allowed to give an illustration of a job I put in some time ago. It was a store where we had to place the heater and heat the store and room above it. The pipe rose up from the heater and pitched down from the highest point directly over the heater. We took an air pipe from that point. We supplied the radiators up-stairs and returned them to the same main and also dropped two other radiators to the same level as the boiler and took a separate return

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from them and carried it back to the boiler. We reduced the circuit main that ran overhead, so that when the end of the main got back from the boiler it, in conjunction with the return main underneath, would have the same capacity as the main leaving the boiler. Of course the radiators on the ground floor would not circulate at first as quickly as the radiators up-stairs, but ultimately, when the circulation was fully established, there was very little perceptible difference in the radiators down stairs and those above. I think the 1-pipe circuit system is more particularly applicable to pressure hot water work. I put in a pressure hot water job the other day. I laid the work out for a man some distance from the city where I am located. But it was the first time he ever installed a system of this kind. He reversed every one of the radiators, connecting the flow end into the first fitting and taking it out on the side, bringing the return back and into the top of the main. When I got down there I felt rather bad over it, of course. We did not have time to alter it. I said, "let us try it." We put the pressure right on it and the job is working satisfactorily to-day. (Laughter).

Mr. Quay:—I suppose that hot water under pressure is a little off the subject, but I am glad it has been referred to. A good many people have advocated the hot water pressure system, and the reason they advocate it is because it is cheap. I went to the expense last winter of testing a job in my own house. I gave it a thorough test in order to see whether it is safe to advocate a hot water job under pressure, and I came to the conclusion that it is not safe to recommend it to the ordinary house-holder.

Mr. Fish:—I would like to shake that man's hand. I have always championed the cause of low pressure hot water heating and assured my friends that there is nothing to be gained in doing hot water work under pressure. I have been through it and speak from experience. Nothing is accomplished by putting a safety valve on the expansion tank. It is a dangerous practice and shows lack of knowledge. If I were a law maker, I would make it a criminal offence to put a valve on the expansion tank of a low pressure water heating apparatus. This practice makes the apparatus more dangerous than if steam were employed, for in erecting a steam apparatus the fitter will put on automatic appliances to govern the pressure and draft, rendering the apparatus practically safe, while with the expansion tank of a hot water job closed to the atmosphere for the ostensible purpose of getting high temperatures and assisting the circulation an element of absolute danger is introduced. I had a case last year where a fitter came to me and said, "I propose

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to put a safety valve on the expansion tank and by that means increase the circulation." I advised against it and pointed out to him his wrong idea of the principles of water circulation. Some years ago I met a case where indirect radiators were broken because the fitter had erected his apparatus to operate under pressure, placing a safety valve on the expansion tank. The excessive pressure from expansion of the water caused them to break, the valve failing to act. When you realize the excessive pressure which is exerted on a job when run under the closed tank system and the danger of bursting a boiler, or perhaps a radiator in a parlor, and doing bodily injury, I cannot understand why it is practiced, and it behooves every member here to discountenance this practice. The fitter will feel more comfortable if he leaves the safety valve off the tank and erects his work on the low pressure or open tank principle, thereby avoiding chances of becoming liable for an accident.

Mr. Payne:—I did not put the safety valve on the expansion tank. I put it on the boiler. (Laughter). Another thing; I do not approve at all of pressure work. I am altogether opposed to it, but there are some conditions under which it may be necessary, and this was one of them.

XXII.—Topic No. 4.

Is it practical or economical to use a fan system in connection with a hot air furnace?

Mr. Jellett:—This topic has been pretty thoroughly gone over in Mr. Kramer's paper.

XXII.—Topic No. 5.

Which is the better practice in a system of hot water warming combining both direct and indirect radiation—to supply all from the same system of mains or separate mains to direct and indirect radiators?

Mr. Fish:—In erecting hot water work it has been my practice usually, where systems of both indirect and direct heating are employed, to run the indirect system on a separate main from the direct system, my reasons being that a better circulation is produced, and the indirect system, being placed on a separate main pipe, can be closed off, repairs made, or operated separately from the direct system, without its being interfered with.

Mr. Jellett:—That has been mv own experience; when using indirect radiation and direct you can get better service by separating the mains. It is difficult to so adjust a system of hot water piping that you can feed direct and indirect equallv well from the same

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main. In a recent plant we ran separate mains to the direct and to the indirect. There are good reasons for that. You get better flow of water, and secondly, on account of the use of the house itself, the piping is so arranged that the indirect system can be drained independently of the other, so that we can use the boiler and the direct radiators to keep the house tempered and drain the balance of the system. There are one or two radiators in the bay windows of the living rooms hidden behind screens. My experience with this system has been that it has been very much more satisfactory than coming from one main.

Mr. Fish:—My practice has been similar; that is, I have always arranged the indirect stacks with two valves, with draw-off cocks for emptying purposes, in case repairs were needed. I would like to ask the members what experience they have had where they have used valves with small holes in the seats on radiators for hot water heating. Many manufacturers are now putting a small hole in the seat of their valves to prevent freezing, and my experience has been that the hole through the seat of the valve permits of sufficient circulation to keep the radiator as hot when closed off as when the valve is fully open. I know one instance where a fitter installed an apparatus and used valves having small holes in the seats, and his customer complained that he could not shut off his radiators, saying the valves were defective, and the fitter was obliged to have the holes in the valves soldered up and made tight before he could collect the balance of the money due him on the contract. Many fitters are using radiator valves with holes in the seat, it being stated by manufacturers that it prevents radiators from freezing, but as it spoils the usefulness of the valves for the closing off of the radiator, I do not think the practice a commendable one, as it causes the fitter much trouble and annoyance. There is not much danger from freezing, if ordinary precaution is exercised.

XXII.—Topic No. 6.

What are the advantages, if any (other than original cost of construction) in a 1-pipe installation over a 2-pipe or a 2-pipe relief system?

Prof. Carpenter:—I had occasion this last year to make a good many inquiries respecting the practice in this country and having all sorts of answers and opinions I came to the conclusion that it was largely a matter of practice of workmen: that if the workmen were accustomed to a 2-pipe system it was cheaper to put that in, and if they were not, that the other was cheaper.

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Mr. Jellett:—I think it is more the universal practice in the West than it is in the East, and I think in view of that fact Mr. Quay would be much better posted than we are here. I would ask for the best experience from the West.

Mr. Quay:—We do nearly altogether 1-pipe work, and in office buildings and buildings where we have room in the attic we usually heat with the mains in the attic and we find the results are perfectly satisfactory, while we often hear men who do not use the 1-pipe work say that it won't work. We think that if they would take the time to come and examine some of the jobs done on the 1-pipe overhead system they would have to take that back, because they do work perfectly satisfactorily. One thing is necessary, however, which Prof. Carpenter has referred to. It is necessary to be more careful in the construction in order to have the 1-pipe system work than it is in the 2-pipe system. The fact of the steam going through the arm of the radiator in one direction and the water going back through it shows the necessity of being very careful in regard to the sizes of your arms and the pitch, while I do not think they have to be as careful where the steam is following the return. Of course I do not like to say very much about the first cost being less, because I do not think that is what engineers should talk about. I think we make a mistake when we put that matter first. I think the first thing we should advocate is doing the work right, and let the first cost come in as a secondary matter. (I was sat down upon the other day on that point, but I did not make myself quite clear. My main idea in advocating the conduit system was that we should advocate the best system first and then the matter of cost.) We have constructed a great many plants for different classes of buildings, especially the larger office buildings, with the 1-pipe system, and I could give you, if we had time, an illustration of some of this work in twelve to sixteen story buildings, where we carry one main up into the attic with the distributing main in the attic and supply down from that point and connect to the return in the basement—usually suspended.

Mr. Fish:—In doing this 1-pipe work is it the question to pitch the radiators toward the main? Do you have any particular pitch? Are the outlets of the radiators specially tapped—that is large tapping—where you use this system?

Mr. Quay:—The outlets are larger than the pipe. The radiator is pitched towards the main.

Mr. Jellett:—I would like to ask what is the usual practice in the West with the 1-pipe system as to the amount of back pressure? I

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take it for granted that they utilize the exhaust. I would like to know what amount of back pressure it is customary to provide for in specifications?

Mr. Quay:—Well, five pounds is considered the maximum. With the use of any kind of a vacuum system to remove air from the radiators we heat from atmospheric pressure. We have two jobs working now where we have connected the Paul system. We are heating both buildings at atmospheric pressure. We set the reducing pressure valve so that it works sometimes a little below, sometimes just at atmosphere. We found quite an interesting experience in this case where the engineer had not been used to heating at this pressure, and during a cold spell he thought he must have two or three pounds pressure. By a good deal of persuasion we induced him to try with atmospheric pressure and set the gauge at that point and it was only a short time when he came up in the building and said: "Our boilers are going to blow off." We told him to open his doors and let them cool down. He has spoken since about the economy of fuel that he has noticed, while not using exhaust steam entirely. But five pounds has been the maximum and very often we carry two pounds without any vacuum system.

Mr. Hoffman:—I live in the West and I know it is the custom almost altogether there, as Mr. Quay says, to use a single pipe system. I have an idea that one of the troubles that they sometimes have to contend with is getting water in the radiators on the descending pipe. If it is very cold the water will suck into the radiators and fill them, and the engineers have more or less trouble in getting rid of this difficulty. If I might step to the board I would like to give a little illustration of a T that I think would overcome the difficulty. (Mr. Hoffman made a sketch on the blackboard).

Mr. Jellett:—I have not seen that particular fitting.

Mr. Hoffman:—You have not seen that particular fitting, because I do not think it has ever been made.

Mr. Quay:—I do not think the water in the radiator is caused by what Mr. Hoffman says. We have heated buildings with temporary steam, 1-pipe system, where the windows were not properly closed and where the buildings were wet and cold, the most unfavorable conditions you could find. In fact we sometimes found snow on the radiators before we turned the steam on—not afterwards (Laughter). But the difficulty is with a pipe either not having the proper pitch or not being the proper size, so that the water is held in the radiator, or not having the proper kind of a valve. We had a little experience a short time ago in regard to the kind of radiator valve that is used. We ordered corner valves, and through a clerical

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error did not say "off-set" corner valves. It was a job out of the city. Our superintendent got the valves and put them on, and he first wrote me that the job was working very nicely. The next day he wrote us that the radiators were holding water and he had found that it was the fault of the valve. If you have noticed the ordinary corner radiator valve, the seat is raised so that it cuts off about half the outlet or the inlet of the valve. Now, this seat of the valve held the water in the radiator, cutting off half the opening, and there was a great deal of condensation and the water could not get back. I had the man take the valves all off and I wrote a letter to the manufacturer, who is one of the best in the country, rather condemning the manufacturer for putting such a valve on the market. He said that in the East they had been using that valve for years and he had never heard a complaint. I said to myself—I did not say it very loud—"I can understand why some people say that the 1-pipe system won't work; they have been using that valve with a 2-pipe system and if they had to put it on a 1-pipe system they would find right away that it would not work." There have been certain tees manufactured and put on the market with the idea that Mr. Hoffman suggests, but we never found it necessary to use them. I think if the piping is properly laid out, proper sizes and proper grades, and all those things considered carefully, that you will have no trouble about the water remaining in the radiator.

XXII.—Topic No. 7.

Does the color of the finish on a radiator materially affect its radiating power?

Prof. Carpenter:—I would say that we made a few tests of the effect of paint on radiating surfaces and we did not find that the color made any particular difference. We did not have time to go through all the ranges of color in as thorough a manner as we should like. I believe we tested bronze, a coat of yellow paint, and of white paint. Regarding the results of these tests, see my paper in which as originally printed there is a mistake in the print. At the bottom of the table on page — it is stated that a given pipe painted with asphaltum 113.5; pipe painted with light drab lead paint 126.7, as compared with unprotected pipe. The figures should be 103.5 and 106.7. The error was due to some mistake of my own, I suppose, in copying. The actual results of our tests showed that in both cases the painted surfaces were somewhat superior to the plain pipe unpainted. Beyond that we have not gone. We have not tested enameled surfaces and I have nothing to add in respect to it.

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Mr. Fish:—It is stated by some authorities that in pipes painted with black the efficiency of the radiator is increased.

Prof. Carpenter:—Yes, sir, we found about three per cent increase in efficiency.

Mr. Fish:—Walter Jones drew my attention to that fact and in his book he points that out, naming ordinary lamp black coating. In bronzing pipes and painting them red and green and having them coated over several times I never noticed any special difference.

Mr. B. H. Carpenter:—I would like to ask if any one has had any experience or made any tests with second or third coatings, and what difference it makes?

Prof. Carpenter:—The bed pipe referred to in my paper was coated with two coats of lead paint. The results seemed to be a little better with lead than with asphaltum. It would seem from a theoretical standpoint that an enameled and smooth surface would have less radiating power than a rough surface, but personally I could not say what the results would be.

Mr. Fish:—Might I ask Prof. Carpenter to explain why, in his judgment, in pipes covered with lamp black or a black coating of lead paint the efficiency is increased? What is the theory of it?

Prof. Carpenter:—I think the same theory applies to all painted surfaces. If you will notice the table on page — of my paper you will see that as the conductibility of coverings increase the amount of heat which is transmitted with certain coverings is increased rather than diminished. That, I think, applies in the same way to the metallic paints. The metallic paints unite very firmly with the metal. They increase the extent of surface and make, perhaps, a superior surface for delivery of the heat into the air, and in that way they increase rather than decrease the total amount of heat transmitted. You all know that the great resistance to the passage of heat from metal into the air is found on the exterior surface of the metal. Anything that we can do to lessen that resistance increases the efficiency of the surface; some of the paints seem to increase the efficiency of the surface very slightly. Whether all paints will can only be determined by trial.

Mr. Hoffman:—There is an old saying that nature abhors a vacuum, and isn't it possibly true that in the rough surfaces of the iron, as it first comes out, there is more or less space which would be very minute, but which would naturally be occupied by what we might term air globules? Now, we know that air will not conduct heat very rapidly. It is practically a non-conductor of heat; and is not that a possible explanation of the non-conductibility or superior-

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ity of the painted surface, because it smooths down the iron and fills up those little pores or openings so that the air cannot stay there?

Prof. Carpenter:—That might be. My idea is, however, a little different, although I am not positive. I had thought that a painted surface might be somewhat rougher than a plain surface; that is, under a very powerful microscope a painted surface might show more irregularities than the unpainted iron and in that way the surface would be somewhat increased by the paint. Perhaps I am wrong. It is a subject I have not investigated at all.

Mr. Hoffman:—I know it is an absolute fact, by test, that so far as a nickel-plated stove is concerned, there is very little radiating power in the nickel-plated part of the stove. I burned my hand one day in trying to demonstrate that. I got down to the stove before I knew I was anywhere near it.

Prof. Carpenter:—It is a well-known fact that the radiating power of polished surfaces is very small. But that is not referred to in this case at all.

XXII.—Topic No. 8.

In a fan system of warming, which is better—to draw the air through the heater or force it through?

Mr. B. H. Carpenter:—I have never had actual tests of drawing through a heater at all, but I have several times forced it through, and from plans that have been gotten out by the people who make fans and heaters, I notice in almost every case which I have seen that they have forced it through, and they generally recommend this method, but why, I do not know. I should like to hear from somebody who has had experience in both cases.

Mr. Jellett:—I do not agree with Mr. Carpenter. I had experience with both blowing air and drawing air through heaters. While it is true that the fan makers' catalogues show more pictures of fans blowing through the heater, the same fan makers, in practice, put up more heaters the other way. The objection to the pulling through in many cases I can illustrate by an example which occurred some four years ago. There was not width enough in the room to draw through. There was a basement area window and the window was built in front of the blower. We found that in wet weather, in snowy weather, when it was particularly cold, that moisture condensed on the inlet of the fan and froze. I found on one occasion when there had been a heavy storm at night, the fan running at very slow speed during the night, that there was ice on the blades of the fan, and when the fan was speeded up in the morn-

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ing, the blades were torn out of the fan by reason of the ice. Now, this is not an isolated condition. I know of quite a number of cases where this same trouble has been experienced. I also find the trouble that at very low temperature of the air you cannot get an oil feeder that will work satisfactorily on slow moving fans. I have had trouble with hot boxes, with grinding out at times, and with the oil not feeding—simply that the temperature was so low that the oil or grease was held and the contact point not being on the shaft, but being fed automatically from above, we got no oil. This is overcome by drawing the air from the heater to the blower. We take the air from out-doors to the heater section, the air striking the first four to six pipes, meeting there the worst conditions. It has been our practice to feed this back section with a larger supply and return with a larger opening. Taking the air through this heater, it enters the blower at a high temperature. The blower is working then under the same normal condition of temperature at all times; the bearings are warm but not excessively warm; the temperature of the air from 130 to 160 degrees. It is not sufficient to affect the bearings in any way. It does keep the oil supply at all times free, and then, apart from that, you have a clear, straight delivery from the mouth of your fan to the ducts. I have found that a clear delivery from the mouth of the blower to the system of ducts gives a better distribution than blowing through the system of pipes first and afterwards to the ducts. My experience has been largely on the side of drawing through the heater rather than forcing it through.

XXII.—Topic No. 9.

As the temperature of the air in heated rooms varies with the height above the floor at which it is measured, is it not better to specify the temperature of the air within a given distance of the floor rather than to say that the room must be kept at 70 degrees?

Mr. Payne:—I always make it a rule to locate the thermometer as nearly as possible in the exact center of the room, and I have never found any party for whom I installed work to object to that, for I always reason that what I guarantee is of course the average temperature of the room. If you try to heat the whole of it to 70 degrees, some of it would have to be away up to 85 degrees or thereabouts.

Mr. B. H. Carpenter:—I think that would vary considerably with the style of heating you are putting in. If you are using one style of heating the difference of temperature may be quite considerable at different heights from the floor, while with another, where it is

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well ventilated and quite rapid, the temperature would be nearly the same if ventilated near the floor line.

XXII.—Topic No. 10.

What number of cubic feet of air per minute can be warmed to a temperature of 160 degrees by a square foot of heating surface in a heating drum?

Mr. Hoffman:—I think that largely depends upon the size of the furnace.

XXII.—Topic No. 11.

In a fan system of warming is there any reliable rule for figuring loss in transmission through horizontal ducts?

No discussion.

XXII.—Topic No. 12.

What is the best method of equalizing a gravity system when steam is generated in two or more boilers?

No discussion.

XXII.—Topic No. 13.

Should not house heating boilers be rated on the number of square feet of grate and heating surface rather than by naming the amount of radiating surface they will carry?

Mr. Fish:—Our catalogue gives all that information. (Laughter). I am not ashamed to put down the square feet of boiler surface and grate surface and let the engineer figure it out for himself, and, if it is too high, cut it down. In a revised edition of our catalogue I have put down the square feet of actual boiler surface in our work, together with the square feet of grate surface and the approximate horse power, so that he who runs may read, I suppose, and figure accordingly.

XXII.—Topic No. 14.

Is the use of the steam loop for returning condensation from heating surfaces located below the water line of boilers of value, and can its field of usefulness be extended?

Mr. Cary:—I do not know how easily I can answer this question. I have used the steam loop and it has worked very successfully. Others have put it in and it has been a flat failure. Where it has failed I have not followed up the method or design. That may be the trouble, but I do not think so. I think there is a great deal in

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the man in charge of the plant. To illustrate: In one plant I placed a steam loop; I had a good engineer and it was very successful. I severed my connection with that concern some one or two years afterwards and the engineer has left them. They have had two engineers since and neither one could make the steam loop work. I think it has to be looked after like everything else and if properly cared for and properly installed I think it is a very serviceable thing, and it is one that I would advocate if I thought it was going into proper hands to be properly taken care of and operated.

Mr. Payne:—I have had quite a little experience in connection with installing steam loops and kindred systems, and I have found that the claim made by the men who were the first to push forward the steam loop is quite true, which is, that the simple steam loop is not adapted for a system but can be handled on one apparatus or possibly two successfully. Then, in following up that idea, Brown & Sharp, of Providence, wished at one time to install a steam loop and they called upon the Westinghouse people in regard to the matter and they refused to put on a single loop to take care of the system. Mr. E. P. Holly, who was then with the Brown & Sharp people, conceived the idea of putting a receiver on the end of the loop and connecting the system to the receiver. He put this in and made a new form of standpipe. Instead of using the regular leg and horizontal condenser with a drop leg, he put up a piece of 6-inch pipe and connected the rising leg to that, making a reservoir at the top and taking a return pipe to the boiler from this reservoir and carrying a pipe from the top of the length of 6-inch pipe to a condensing coil, which is used for the purpose of having the steam flow to supply the condensation in the coil and so carry the water to this point.

There is a system in Pawtucket, R. I., which is taken care of by the steam loop. But to do this they have had to put in eight or nine loops. When we take into consideration the condesation in all of the various condensing portions of these loops I think we have got a pretty extravagant apparatus. All this takes a considerable amount of steam and the question in my mind as to the advisability of using the loop in that manner is whether it would not be more economical to use a pump. Mr. E. P. Holly, in following out the idea before referred to, has developed it a little further and instead of using the condensing coil he places a reducing valve on the top of the 6-inch standpipe, carrying the steam from this reducing pressure valve over to a feed water heater or somewhere else, or, as it has been installed in this city, he throws it out of doors. Under certain conditions I believe this is a very extravagant method also.

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I have seen it in operation where the amount of steam wasted was fully sufficient to run a pump doing the same amount of work. Should the system become flooded, instead of the water returning to the boiler, it will very frequently blow out through the reducing pressure valve.

There is still another system which has been developed and which has been put through the patent office by a man named George Parker and I think his idea of the matter will prove much more successful than either of the two former. I have seen it in operation, and whereas in the other two systems they provide a blow-off valve for blowing out the system as soon as it becomes flooded, I have seen the blow-off pipe in the Parker system put on, but capped on the end so that it is impossible to use it, and it was only last week I was looking at a system where it never yet has been blown off since the first time it was started. If it becomes flooded it starts itself. You still have a waste of steam which of course is absolutely necessary. You must have some energy to do the work. But the waste is very much less than in the other two methods. But Mr. Parker is not pushing his system at present because he has not experimented with it and cannot say exactly what it will do. The Holly Steam Engineering Company are putting in their system, but if they put it in in connection with a condensing coil they have not yet got to the point where they can say how much of a condenser is necessary to do a particular amount of work. I have known several jobs they have put in, starting with a given amount of condensing coil and keeping increasing or decreasing it as the cases might warrant until they happen to strike the right amount.

In regard to the statement just made that the cause of a steam loop not operating would possibly be the fault of the engineer, there is another condition, I think, which must be considered. If you make a pocket in your pipe, or if the pipe should sag and form a pocket in it and collect water, and suddenly throw it and cause a flooding, it would stop. In a great number of instances where the system has failed to operate, if it is looked into, you will find considerable trouble in the piping. In Baltimore there was a system erected for the General Electric people and when it was first started it operated satisfactorily. Then it suddenly stopped, and the sudden flow of water to the cylinders very nearly caused a serious accident. We sent a man down there to look over the job, and he found that there were slip joints put on. I think it was either a 1½ inch or a 2-inch pipe and it had not been properly supported; the piping had sagged and caused a pocket and that had collected water, which, when driven over,

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flooded the system, which of course stopped the whole affair. He took this out and put in a piece of bent pipe about twelve feet long which provided for expansion and did not form a pocket. I think this is a very wide subject, and it is very possible that the system will be used in the future with good results; but it requires a large amount of experimental work to determine the exact value and the exact proportion of the various apparatus.

Mr. Barron:—I think I suggested the question. I had occasion lately to take the drip from a large pipe below the water line, low-pressure, working at ten pounds pressure, and I had to decide whether I should use the steam loop or an automatic trap, and I decided to use the automatic trap for the reasons Mr. Cary gave.

XXI.—Topic No. 15.

What quantity of water should sectional house heating steam boilers contain in proportion to their grate and fire surface?

McClellan Davidson:—In considering this subject the first step to be taken will be to consider the grate surface and its relation to the heating surface, or absorbing surface, as you please. In boilers of the present day the absorbing ratio is anywhere from 15 to 60 to 1 of grate, the first instance representing a loss of fuel, the second instance a saving, or at least intended to be. But if placed indiscreetly, allowing opportunity for soot to accumulate upon these surfaces, they naturally become ineffectual for heating, aside from the fact of offering obstruction to the products of combustion, impairing the efficiency by sluggish draft. In view of the aforesaid it would be necessary to take some standard in order to arrive at a proper solution of the question. A boiler absorbing only 800 units is not as effectual as one in which the absorbing surfaces will utilize 1,000 heat units per pound of coal consumed. Therefore, in the first instance, one-fourth less water would meet the demand. One square foot of grate surface will consume from five to ten pounds of coal per hour in a good boiler. Eighty thousand B. T. U. can be made available in reconverting the entailed water into steam with a consumption of eight pounds of coal, or the complete evaporation of eighty pounds of water per hour, assuming the return water to be at or about 200 degrees. If the radiation attached to the boiler demands this amount of steam, it naturally follows that, the demand and supply being equal, you cannot have a reserve. Hence, the necessity of supplying an additional amount as a factor of safety in overcoming rapid firing, filling of mains and radiators with steam, low water, a possible false line, etc., all of which should be taken from the boiler without lowering the water line to a point of

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danger. This factor of safety I consider equal to one-half the demand made upon the boiler, which is 80 pounds plus 40 or 120 pounds per square foot of grate. If we get too small a quantity of water, requiring excessive boiling to meet the demand upon the boiler, it becomes an objectionable as well as dangerous feature, foaming being a direct result of rapid firing or insufficient water. In other words, it is a result of overheating the water. When surfaces become heated to a high degree the water is repelled, as it were, caused by the formation and explosion of steam particles at the base of the water column, which is the fire surface of the boiler. Too much water carries with it a train of objections also, such as length of time necessary to get up steam, being sluggish in circulation and offering opportunities of deposit, and the impossibility of obtaining dry steam. I have never been able to obtain any literature bearing directly upon this subject. Writers who give steam heating and boiler construction any consideration say that boilers should contain water to fill all mains, risers, radiators, etc., with steam, without lowering water line to such an extent as to require attention. It strikes me that this is a subject which calls forth our engineering talent, and I, for one, would appreciate the opinions of this society upon the subject.

Mr. William Kent:—I have not had much practice with sectional house heating steam boilers, but from what little I do know I do not think that they differ materially from boilers used to drive steam engines. The question what amount of water should be contained in a steam boiler generally is one that has been answered all the way from no water at all up to an enormous amount. Boilers have been driven, I understand, with no more water in them than merely a jet sufficient to keep the plate wet. If you have a series or sectional boiler and can manage to keep the tube wet you can run the boiler with no more water than that. In fire engines—engines for putting out fires—the object is to have as little water as possible in the boiler in order to get up steam quickly. I have seen boilers with drums piled one on top of another where there would be ten tons of water to heat up. The question of how much water you have in your boiler beyond the amount necessary to keep the heating surfaces wet is one of how fast you want to raise steam. When you begin to fire up, if you are going to be in a place where you have to suddenly raise steam, to do it in fifteen minutes or so you want very little water in the boiler. If, on the contrary, you have a rolling mill that is running night and day there is no objection to firing up the boiler twelve hours before you start the mill. It is a question there of reserve capacity. The question is how much of a reserve

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capacity do you have? So there can be no law laid down for boilers for steam engines or boilers for other purposes. In steam boilers for steam engines you will find in the market to-day probably a ratio of ten to one between the different amounts of water prescribed. You will find in use vertical boilers with very little water in them and other boilers, like the Scotch boiler, with a great deal of water. One has a great reserve of power in emergencies and the other has not. So that the amount of water you put in a boiler depends on how much fluctuation you expect in the demand for steam.

XXII.—Topic No. 16.

Should not the opening through the seat of all radiator valves be equal to the inlet and outlet, and should they not be constructed so that no water will be held in the radiator by the seat of the valve?

Mr. Barron:—I would like to ask if there is any one here who has had much experience in using gate valves on radiators and what that experience has been. I have used them and found fair results. I would like to know if others have done the same?

Mr. Gormly:—I would say I have had some experience in the use of gate valves in water radiators and have found them to work very successfully, except in places where it was necessary to run the temperature very high and say 25 or 30 pounds pressure. In that case I found that the gates had a tendency to rattle and made the jobs noisy. I never used them on steam, so I can say nothing for them in that respect.

Mr. Payne:—Wherever I have found it necessary to set a radiator at a distance from the riser and having to carry the connecting pipe over the floor to the radiator, I generally try to use a gate valve with a wood wall. I have found very good results from them and I think it is about the best method unless we can use an angle valve. In regard to corner radiator valves I had the same trouble of which Mr. Quay has spoken in regard to the seat being raised up on the valve. I ordered some corner valves and they were made in this way, they were put on the job and of course we had to take them off and get the off-set radiator valve. I am sure I cannot see why manufacturers should send out valves made in this manner, because I think they are worse than nothing. I think this question almost answers itself. I hardly imagine that any person will want to use a valve of a less opening than the inlet and outlet, though in a great many cases we do use it, but the nearer the opening of the valve approaches the inlet and outlet I should think we all agree would be the better.

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The President:—There is the latter portion of this question, Mr. Payne—that no water be held in the radiator by the seat of the valve.

Mr. Payne:—Most decidedly.

XXII.—Topic No. 17.

Which are the most effective, float or expansion automatic air valves?

Mr. Barron:—From my experience none of them are effective. (Laughter). There is no question but nearly all the makes of valves are used and give very good results. In the flat where I live there are three different makes and they give no trouble. In the office I use another make and it gives no trouble. The valves are not uniform. You get from a manufacturer a valve to-day and it is all right. Next week you get a valve and it is not right. It has a float that will not let water out—water will come out, and all the skill in the world will not make that valve work. I think it is due to the fact that valves are not made uniformly; they do not have fine jigs and all that sort of thing with which to turn out fine work. I think that if the construction of air valves were confined to the state of Connecticut they would be all right. (Laughter).

Mr. Payne:—Answering the question, I think a combination of the two is very desirable.

XXII.—Topic No. 18.

What is the best method of heating and ventilating schoolhouses accommodating about 200 pupils?

No discussion.

XXII.—Topic No. 19.

What are the relative merits between flue radiators and other types?

No discussion.

XXII.—Topic No. 20.

What should be the proper form and area of chimneys for house heating boilers in proportion to their grate surface?

Mr. Cary:—I think that we have an authority on the subject of chimneys with us, Mr. William Kent, and I would suggest that he be called upon to answer this question. I do not know of any one who can do it as well as he.

The President:—Mr. Kent, gentlemen, is an authority on the

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subject of chimneys, as I think we all know. I have stolen some of his thunder.

Mr. Kent:—The only extent to which I am an authority is that it happened twelve or fifteen years ago that I studied up all the different formulæ on chimneys and all the tables and compared them with a great deal of existing practice, and from that deduced a formula and table which has been very widely received by the profession since, and I have seen no reason to modify the table except to extend it and make it larger. With regard to the question, "What should be the proper form and area of chimneys for house heating boilers in proportion to their grate surface?" First, the proportion to the grate surface. They should not be proportioned according to the grate surface at all. That is one of the troubles that we have had in chimneys for all time. We will build a boiler and a chimney and make the area of the chimney one-eighth of the grate surface and get along all right, and then we will get another coal and find that that coal is better burned with one-half of the grate surface, and then the ratio is one-quarter the area of the grate, and the chimney works all right still. If you get it down to one-eighth you will find no end of trouble. The chimney must be proportioned to the maximum amount of coal that is intended to be burned on the grate. Sometimes you will burn five pounds of coal per square foot of grate per hour. At other times you will burn four or five times that much; in locomotive practice you will burn twenty times as much. But the chimney must be made large enough to take out the gases, and the gases do not depend so much on the amount of grate surface as on how fast you drive the air through. In steam engine practice we have an arbitrary figure called the horse power. I do not think they adopt that in heating practice. But the formula that I have given and the table that I have given for horse power of chimneys I would say would be exactly applicable to house heating boilers, if for horse power we substitute five pounds of coal per hour. I have not the formula in my head but you can find it in Prof. Carpenter's book and in my own, and nearly all the prominent boiler makers publish this chimney table of mine, so that if you take that chimney table and instead of so many horse power multiply it by five and the number of pounds of coal burned per hour, that chimney will be big enough.

In regard to the best form for chimneys I do not know; I do not think anybody else does. The form of the chimney I have found generally depends on geographical considerations. In Erie, Pa., they build chimneys broad at the top and narrow at the base. In other places they are narrow at the top and wide at the bottom.

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They are all good. The only thing is to make them high enough. Our old rule was to make the chimney 80 feet high and as much higher as the owner will pay for. There is one thing that I hope engineers will continue to do and that is to hammer the architects. Architects will never know how to build chimneys. They will always make them too small in area. They may make them high enough; you can scarcely ever have a chimney too big; but you may have it too little. I have never yet found a case where the table I have given was found to give too small an area.

Prof. Carpenter:—I would say that I took the liberty to compute a table from Mr. Kent's formula which I adapted to steam heating boilers, and it is given in connection with the discussion so that it can be used. (See Table X.) I also printed it in my book. I printed

TABLE X.

DIAMETER OR SIDE OF CHIMNEY IN INCHES REQUIRED FOR VARYING AMOUNTS OF DIRECT STEAM-RADIATING SURFACE.

Height of Chimney in Feet.		20	30	40	50	60	80	100	120
Square Feet of Steam Radiation.	Horse-power.								
250	2.5	7.4	7.0	6.7	6.4	6.2	6.0	6.0	6.0
500	5.0	9.6	9.2	8.8	8.2	8.0	6.6	7.3	7.0
750	7.5	11.3	10.8	10.2	9.6	9.3	8.8	8.5	8.2
1,000	10.0	12.8	12.0	11.4	10.8	10.5	10.0	9.5	9.2
1,500	15.0	15.2	14.4	13.4	12.8	12.4	11.5	11.2	10.8
2,000	20.0	17.2	16.3	15.2	14.5	14.0	13.2	12.6	12.1
3,000	30.0	20.6	18.5	18.2	17.2	16.6	15.8	15.0	14.4
4,000	40.0	23.6	22.2	20.8	19.6	19.0	17.8	17.0	16.3
5,000	50.0	26.0	24.6	23.0	21.6	21.0	19.4	18.6	18.0
6,000	60.0	28.4	26.8	25.0	23.4	22.8	21.2	20.2	19.5
7,000	70.0	30.4	28.8	27.0	25.5	24.4	23.0	21.6	20.8
8,000	80.0	32.4	30.6	28.6	26.8	26.0	24.2	23.4	22.2
9,000	90.0	34.0	32.4	30.4	28.4	27.4	25.6	24.4	23.4
10,000	100.0	37.0	34.0	32.0	30.0	28.6	27.0	25.4	24.6
15,000	150.0	....	....	38.4	36.2	35.0	33.0	31.0	29.2
20,000	200.0	....	....	43.0	42.0	41.0	37.0	35.0	34.0
30,000	300.0	....	....	....	50.0	48.0	46.0	43.0	41.0

For other kinds of heating multiply the radiating surface by the following factors: Hot-water heating 1.5, indirect steam 0.7, hot-blast heating 0.2.

it two ways—with the argument in horse power and also the number of square feet in direct radiation. Practically we get about one-third of a pound of steam condensed from a square foot of radiation per hour, so that very nearly one hundred feet of direct radiation requires about the same amount of steam as one horse power. Hence it is very easy to reduce horse power to square feet of direct radiation and then, by multiplying by the other constants which are given, we can change from direct to indirect. The chimney formula has been found very satisfactory in my practice.

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Mr. Wolfe:—Do you not believe that every chimney has a round draft? In other words, is the corner of a chimney of any use? Of course, in our business it is not so much in the draft of a steam boiler as it is for moving air. I have found the draft coming down in the corners and going up in the center and two or three different drafts at the same time in the same chimney, and in noticing factory chimneys it has seemed to me that all smoke coming from the top takes a spiral form, and as to the form of the chimney, don't we get the best results the nearer we keep to a circle? I ask that simply as a matter of information. I do not know; but I would like to.

Mr. Dean:—I will give a case that I had at one time. I was putting in a boiler for 900 feet of steam radiation. The owner asked me if the chimney was large enough. The opening seemed to be at least 12 inches square. I said, "Yes, it is plenty large." But later developments showed that there had been a fireplace in the room above and that an opening from it extended down into the cellar and instead of being 12 inches square the opening was perhaps 12 by 20. When we started to connect the boiler I put my head through the opening and looked up the chimney and it looked to be about two inches wide by two feet. As a matter of fact it was four inches by 24 inches. I told the owner I did not think the boiler would work with that chimney. He said he would change it if necessary—it was on the outside wall—but to go ahead and connect the apparatus up and try it. We made the connections and when we made a fire it was only about fifteen minutes until the boiler was blowing off. It was just as good a draft as I have ever seen on any chimney. I thought possibly it was due to the fact that there was a large opening at the bottom so that when the smoke went in it had a chance to distribute itself and enter this narrow flue at its full area.

Mr. Payne:—I once connected a boiler to a chimney which measured 4 by 30 inches the whole way out. It was not a success.

Mr. Dean:—I should like to ask the gentleman if the smoke pipe was simply the chimney or if there was a large opening made so that the smoke would have a chance to squirt out.

Mr. Payne:—It was 4 by 30 inches from the base to the top.

Mr. Kent:—I was once called in to find the trouble with a boiler that had not enough draft and I found that it was connected with a chimney eight inches square. I found that right alongside of the chimney was another chimney also eight inches square separated from it by a 4-inch wall, and I recommended that they take out the 4-inch wall and turn it into an 8 by 20-inch chimney. This was done and it was a complete success.

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As to the question whether a round chimney is not the best, I think there is no doubt of that for the reason that a round chimney offers less frictional resistance than a square one; but as we can make water flow through a square tube just as well as through a round tube, so a square chimney can be used provided you make it a little larger in area than a round chimney.

Mr. B. H. Carpenter:—I should like to ask, in the case Mr. Kent speaks of, whether if that partition had been taken out part way it would have been as successful? I ask this because in one case where we were putting in a boiler there was a chimney of that kind, except that at the base it was separated probably 15 feet and it ran together at the top, and the combined area was hardly large enough for the boiler. But the owner thought that he would run the risk and make the trial and if it would not do would build a chimney outside. We cut the division out for probably five or six feet down from the top and did not have any trouble.

Mr. Kent:—I would say that any length that you cut out of that partition would be a help and the farther you cut it out the better. If it had been cut still farther down a little more draft would have been had. The partition simply acts as a damper where it is placed.

Mr. Gormly:—I would like to give the gentleman a little experience I had with a chimney. We put in a steam heating plant in Utah Territory, and I thought I had a direct flow all the way out, but when we undertook to fire up we could not get a draft. After considerable investigation I discovered two flues built side by side, which we thought were separate and distinct flues. We found that there was a communication between these flues about three feet long and probably eight inches wide. The result was that instead of drawing through the grate we found that there was a draft down one of those flues and through this opening at the bottom and into the other flue and out. When we closed off the top of one of those flues we then had an excellent draft, using one chimney and leaving the chimney broken out as it formerly was. We had another case only last week in which we were unable to raise over five pounds of steam in a place where we wanted to run twelve. After considerable investigation we found that at a number of places in the chimney the brick was laid so loosely that it would blow a candle flame right in when there was fire in the heater. I thought that as the discussion has run on to the divison in chimneys I would say it is rather a delicate thing to attempt to run two flues with a partition between them. That has been my experience.

Mr. Cary:—In the matter of flues, discussion can be continued

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without end almost. The subject has come before the Mechanical Engineers and I don't know that they were much nearer the end when they finished than before they started. As to the matter of a chimney being four inches wide and some 24 to 30 inches the other way, I think the success of that chimney should be attributed to a very small boiler being used. The area was in excess of the area theoretically required by Mr. Kent's formula. This being an outside wall probably the gases as they entered were condensed by being chilled and that, of course, affected the chimney draft. The higher the temperature up to the neighborhood of 550 degrees the better draft you get, but the gases were probably condensed and then, after that condensing took place, there was probably temperature enough to produce all the flow of air that was required. I think there are a good many inexplicable matters relating to chimneys. In Mr. Kent's treatment of this subject he does away with some of the more complicated formulas in taking care of friction, by allowing for it a 2-inch space all around the inside of the chimney; that is, taking the radius of a round chimney, for instance, and drawing a concentric circle in the chimney with a space two inches all around; the space within the inner circle is considered a draft area free from friction. This matter of friction in a chimney is one to be avoided. I know of an instance where the chimney was peculiarly constructed to serve a double purpose. In the center of the chimney a wrought iron flue was built running from the basement, where the boilers were located, to the top. Outside of this it was a square flue and it was tapped into each floor to serve for ventilating purposes to draw the air in from the various heaters all the way up, and it served for that purpose for a number of years. They were obliged to increase the size of their boiler plant and they thought that they could use the inside flue as well as the outside one and get all the area wanted. But when they got the boiler they did not get the results, and they were in a great deal of trouble until they pulled out the interior lining of the flue. Then they got all the draft they wanted. This is a case that comes up when you get bad results by having divisions coming through parallel flues, but by trying to use the two parallel flues individually, on account of the friction, you will not get good results.

Mr. Kent:—In regard to that flue four by 30 inches all the way up, my formula would show that it would not draw at all, because my formula allows two inches all around for friction, and taking two inches all around means no area.

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XXII.—Topic No. 21.

In a 1-pipe system of steam heating, which works better in practice—a sealed tank return or a vented tank return?

Mr. Barron:—That is the 1-pipe system, as I understand it. That represents pressure and exhaust steam combined.

The President:—I should think so.

Mr. Barron:—I think that the sealed tank is the only proper way. You do not want to waste any heat, and there is no difficulty in making a sealed tank work successfully with a pump governor or a pump without a governor.

XXII.—Topic No. 22.

What is the difference between convection and radiation in the number of heat units given off per square foot of surface by steam under five pounds pressure?

Prof. Carpenter:—I had occasion to look that up in connection with my book on Heating and Ventilating Buildings and the only experiments I could find were by the French writer, Péclet. I gave those very fully in my book. You will see that they depend largely on circumstances. That question could not be answered without taking into account a great many things. As his experiments seem to agree very well with our recent ones I think his results are quite reliable. There does not seem to me to be any relation in these experiments unless you assume some condition which is not given here or else determine what your radiating surface will be.

XXII.—Topic No. 23.

In what location are the best results obtained from hot air flues—outer walls or inner partitions?

Mr. Wolfe:—We pretty generally have understood up to within a comparatively short time that the location for a warm air flue should be in the inner wall. My own opinion is that it does not make any great amount of difference where you are bringing the warm air from in warming a building by an indirect system; no matter how you heat the air it will naturally rise to the ceiling. Naturally it will drift to the outside or exposed wall, and the more pertinent question is where shall we take it out to cause the best distribution of the fresh air throughout the room rather than where shall we let it in. We all know that if the register is in the floor in any part of the room that the warm air will go to the ceiling first. Its drift will be—provided there is an outlet—first to the outside surface; from that point the drift will be naturally towards the outlet.

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getting its power from the power of the outlet and the additional power of the force of the inlet and the increase by gravity or its extra weight in the fall. The Massachusetts inspectors recommend that the inlet should be adjacent to the outside wall on an inner wall. The objection to a floor register is that it does not add anything to the purity of the air to have it pass over the clothing, shoes, etc., of people who will stand on it. If it is low down it comes in with a velocity which makes it disagreeable to sit near it. Consequently, I think that a warm air flue or an inlet flue can be placed anywhere above the seven foot line and insure a pretty good circulation. But it is more important, in my opinion, as to where to take the air out than as to the point to bring it in. Permit me to locate the outlet of proper capacity and power, and you locate the intake, and I can warm and ventilate the room, but with control of inlet only I could not be sure as to results.

Mr. Jellett:—My own experience is that a modern house is a house without doors on its inner walls; that is, there may be sliding doors that are generally open, so that you have to consider the house as a whole. The hall being an open space leading to the upper floors of the building, there is a greater aspiration in the halls than in any other part. The average house, also, is not provided with outlets. There are very few residences to-day that have a complete system of outgoing flues. These being the known conditions under which we are asked to work, I would prefer to get my flues in the outer wall for two reasons. The first one is that as houses are constructed we can get a cheaper and more effective flue. The second one is that the form of hot air register used to-day will shut off a larger proportion of the area of the flue than we can get into an inner partition, unless we use an extended register, and they are considered very unsightly and are generally objected to on that ground. The average partition is a four or five inch partition. The average register box is $2\frac{1}{4}$ to $2\frac{1}{2}$ inches in depth. If you allow for plaster on the back of your flues you have less than two inches in depth to your flue and therefore your flues are cut down to a very small area. The studding is placed twelve to fifteen inches apart, so that you are limited to four inches in depth and an extreme of sixteen inches in width. It has been our practice in doing work of that kind to place flues in outer walls, to make a hollow backed flue and fill the hollow back of the flue with mineral wool or something of the kind. I have in mind a case of three large hospital buildings where I made the plans for heating and ventilation. It was absolutely necessary to lead through the outer wall. The hollow backed flues, such as I have described, filled the space. We

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got very satisfactory results with flues erected in this manner, but we did not find satisfactory results with flues on the inner wall from the fact that we could not get sufficient area to make the flue effective.

Mr. Connolly:—I do not agree with Messrs. Wolfe and Jellett, having had an extension to a city house with three bath rooms, second, third, and fourth floors, heated by indirect hot water. Upon the advent of cold weather the house was thoroughly heated, with the exception of the third and fourth floor bath rooms, which were down to a temperature of 50 degrees. The separate pipes for those two rooms were placed on the outside wall, with a double back packed with mineral wool and four inches to the weather. The second floor bath room with a pipe in the inside wall was at a temperature of 70 degrees; each pipe was supplied from a separate compartment of a stack of indirect radiators in which circulation was thorough, and special provision for ventilation in each bath room was made. To improve the heating of those two rooms an 18-inch fan was erected to the mouth of the cold air inlet, disconnecting the power wire from an electric house pump not in use, and connecting it with this fan; after a fair trial of forcing air through the stack the third and fourth story bath rooms were still uncomfortable. As a final remedy an auxiliary stack of radiators was placed at the base of those flues, using the heated air from the original stack as a cold air box for the auxiliary stack, thereby superheating the air. After this change the fan being started, the two bath rooms were heated; so from that experience I would not advocate hot air flues in outside walls.

Mr. Jellett:—In answer to the last speaker I would say that I never put a flue in with only four inches of outside wall. It is against the law in our section of the country to come within that limit. We must have nine inches of back always on outer walls. Four inches of brickwork is little or no protection to the flue. The outer walls have a certain thickness in proportion to the height, so that usually we find that we never have less than nine inches back of the flue.

Mr. Connolly:—All I would say in answer is that in ordinary buildings the walls on third and fourth floors are not over twelve or eight inches and naturally there would be only four inches to the weather. They may, of course, build walls thicker, and use more brick in Philadelphia than in New York.

Mr. Wolfe:—Mr. Chairman, I only want to explain my position in the matter. I have had to do with but one dwelling house in ten years. When I speak of my experience, it has been entirely

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in connection with buildings that have a system of ventilation—nothing to do with dwelling constructions at all. We have worked under a guarantee as to a given amount of air and the circulation, and we are held down in Massachusetts by a law which compels the circulation to be practically perfect. We are bound to comply with the Massachusetts law, and while it is not stated in the law, it is stated in the requirements of the police department that the air in any part of the room shall be within .0006 as pure as it is out of doors. Naturally we have got to work to get a pretty good distribution or we do not get our money; so that anything I said in regard to the inlet and outlet, etc., referred only to buildings which have a system of ventilation embodied with them.

Mr. Kenrick:—Referring to what Mr. Wolfe has said, the last job I settled in Massachusetts the committee required a certificate from the state that was satisfactory to them in every respect before we could get a cent. They not only take the temperature through the sides of the room but they have a thermometer right in the center of the room, and not only in regard to circulation must the requirements be fulfilled, but the temperature of the incoming and outgoing air is figured against us.

Mr. Payne:—Is it not a fact that, if you take a room with only one side exposed and you blow your air in from outside wall and exhaust it from the floor on the same side, you will get a more uniform temperature in the room than if you blow it in from the inner wall toward the cooler wall and take it out from the bottom of inner wall? It looks to me as if that is so. I would like to know if it is correct. I have a theory, and I have not had the opportunity of testing it, that if the air is blown in from the outside wall of a room, where there is only one exposure, and exhausted from the floor on the same side it will give a better average temperature throughout the room than if it is blown from the inside wall towards the outside and then exhausted on the inside wall also. The reason is that you blow the air over towards the cooler wall and it drops down and becomes cool and passes along the floor to the exhaust; whereas, if you blow it towards a warm inside wall and it drops down, the cooling effect will not be as great and your exhaust register being at the base of the cool wall will draw the cooler air off quicker and warmer air will pass along the floor.

The President:—Can any one answer that question. If not it will have to be brought up at the next meeting.

XXII.—Topic No. 24.

Up to what point will large piping effect an economy for heating purposes?

No discussion.

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XXII.—Topic No. 25.

What is the relative fuel economy of different systems of school house heating and ventilating?

No discussion.

XXII.—Topic No. 26.

Are float traps discharging to atmosphere more reliable than pot traps?

Mr. Barron:—I suppose you see that the object of the question is to find out whether there is such a thing as a reliable steam trap, and I am afraid that that question cannot be answered at present.

Prof. Carpenter:—In other words, I suppose you mean that it is doubtful whether there is any trap that is perfectly reliable.

XXII.—Topic No. 27.

Should not the form of hot air registers be changed so as not to reduce the area and efficiency of shallow flues?

Mr. Jellett:—Mr. President, I think the form of hot air registers as used at present should be changed. I believe the old-fashioned slide register was more satisfactory in delivery of air than the present register. But the design of the old-fashioned register could not be used today. People would not have it. The present registers have, in most cases, three valves in a register twelve inches wide. In order to make a clearance for those valves, the form of the register box has to be deepened, the result being that the entire depth through the register is 2¼ to 2½ inches; add to this the fact that the castings are made square, forming a square edge on the inside, and there is also a great deal of resistance. It has been my practice to make the outlet register two and a half times the area of the flue itself and round the top of the flue so as to guide the air towards the opening in the face; but I find that there is considerable resistance and a very decided variance in the delivery of the air over the face of the register. We take the average of the anemometer readings over the face and it varies very considerably. The suggestion was made a year or two back that the inner side of the castings be tapered; that is, that the thickness of the metal be tapered on the inside very similarly to the tooth of a gear for example, narrowing so as to form a funnel and enlarging to the opening of the register—enlarging from the inside out. In doing this you could reduce the friction of air passing over the surface, but until we can get some other form of a valve and reduce the depth of the casting, I do not think this would be any great

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benefit. We are all called upon to put up flues in very narrow spaces; we are limited as to depth and as to width. Therefore we cannot afford to give up any of the space. It strikes me that if some form of register was devised by which the entire back of the register could be hinged at the top, when the register is open, swing back the entire depth of the flue and allow the air to come in, it would be an advantage. Some such register as this need have nothing but the face and the flat valve at the back and one valve for the entire register; that valve, opening always in the direction of the incoming air, serving as a guide for the air, driving it forward. I offer that as a suggestion, because I do not believe that the present registers are as efficient as they should be. I think we lose a great deal of our efficiency in the delivery of air through registers, particularly at low velocities. If any other member has a suggestion to make of a better form of register than that I would like to hear from him.

XXII.—Topic No. 28.

What is the cause of priming or foaming in house heating boilers?

Mr Cary:—I am not so well acquainted with house heating boilers as I am with boilers of larger capacity, that is, running may be from 25 to 50 horse power. They are both boilers, and I do see that the conditions in one would be different from those in the other. They are both vessels in which you put water and put a fire under the water to generate steam. The conditions are generally the same. The matter of priming and foaming is very often confused by people. Priming is sometimes called foaming and vice versa. Priming is essentially the drawing of water along with the steam as the boiler is in operation. Foaming is caused by some chemical change in the boiler, or from other sources, such as the introduction of oil with the feed water in the boiler, and certain chemical impurities in the water will cause the boiler to foam in a similar manner to soap; as you rub soap in a basin you produce a froth or foam, and this sometimes occurs in marine boilers where salt water is introduced in boilers that have been using fresh water or the reverse. I do not see how foaming could occur under any other conditions. Those are the principal conditions which would produce foaming. Priming would be caused by an insufficient evaporating surface. If the steam leaves the water at too great a speed it will pick up water with it, on the same principle as the old rope well in which we revolve an endless rope into the well and the water is picked up and clings to

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the rope. When steam leaves the water rapidly it picks up little particles of water with it and carries them on, being held in suspension by the velocity. If your evaporating surface is too small this will occur. If you force your boiler you get in the end about the same results. If you force it too far it will cause a violent agitation on the surface and the water will be picked up from the crests of the little waves formed, dashing up against the side of the boiler around the evaporating surface, or the steam will be driven from the surface of the water too rapidly to produce dry steam. These are the conditions in larger boilers and I do not see but that the explanation will apply to house heating boilers as well.

Mr. Dean:—I wish to tell of an accident the effects of which I saw and which might possibly explain similar cases in other boilers. I called at a residence and was looking at the heating apparatus. The man was showing his new boiler to me and also an old one lying at the side of the cellar. It was not very old either, but it had been discarded. Upon inquiry I learned that while using the old boiler he had heard a noise in the cellar and started down. When he got to the stairway he found he could not go down because water was flowing from the safety valve. An examination of the boiler showed that there was no chance for circulation of the water, and consequently the hot fire which he had at the time the accident happened simply lifted the water right up and blew it out of the boiler through the safety valve. It being a pipe boiler when the water got out the fire very soon spoiled it.

Mr. Kenrick:—I would say that I had a case within a month caused entirely by core sand. In the first place we supposed the priming was caused by oil. With that in view, the boiler was blown off fifteen times. Finally we made a surface blow, made an examination of the water, and found it was core sand in the water which, probably in blowing off, was left as a deposit in the sections and then in filling up the boiler it floated on the surface; but by making two surface blows the boiler was made perfect.

XXII.—Topic No. 29.

Is indirect radiation satisfactory in hot water heating?

No discussion.

XXII.—Topic No. 30.

Which is the best method for return of condensation from fan heaters to boilers, gravity or non-gravity?

Mr. Connolly:—To promote discussion in regard to this question

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I understand from Mr. Barron that he said gravity would be more economical. Am I right?

Mr. Barron:—If the circumstances would allow you to do it.

Mr. Connolly:—I bring up the point that non-gravity would be better. The hotter you bring the water back to the boiler the better results you get, and it would be more economical.

Mr. Payne:—That depends on the amount of steam you have got to expend to get the water back.

XXII.—Topic No. 31.

What is the relative difference in economy between automatic return traps, pumps and receivers, and gravity return of water of condensation?

Mr. Barron:—(Referring to topics 30 and 31.) Both these topics should be taken together, for while there is a slight difference we all know that there is a good deal of difficulty in returning the water from fan heaters if you do not use a pump. It is sometimes tried to return the water by gravity and sometimes by automatic drips. Then the relative economy of the three ways—if you can return satisfactorily, of course—the gravity is the most economical. If you cannot, I should think the automatic trap was the next most economical; that is, if you can make the trap work and you have a first class man and can monkey with it all the time, and in that case the pump becomes the most economical because it insures satisfactory work.

Mr. Dean:—I would like to ask why they cannot return by gravity.

Mr. Barron:—You know, as fan heaters are generally located, Mr. President, the fan heater is usually on the same line as the boiler floor. Of course you can return where it is convenient to locate them in that way, but that is not often the case.

Mr. Payne:—I had occasion to express an opinion for a church society regarding the best methods in which to arrange their heating. They intended to adopt a blower system, and the specification as drawn up by several heating concerns called for quite an elaborate outlay for pumps and receivers, etc., and I advised them as the most simple method to put their boilers in a pit, giving sufficient head-room; after looking the matter over they decided to do so, but they found, if they put the pit down it would cost them $3,000 to make it water tight, so they decided to have the pumps, traps, etc. Of course we all know that a gravity apparatus is best, but the conditions are not always such as to permit that.

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ADDENDUM

TO PAPER ON

THE LITERATURE OF HEATING AND VENTILATING.

BY H. J. BARRON, NEW YORK.

(Member of the Society.)

(Inadvertently omitted from Vol. I of the Transactions of the Society.)

After preparing the above paper on "The Literature of Heating and Ventilating," it occured to me that as a considerable part of the paper dealt with English practice the views of an English engineer would be decidedly valuable. With this object in view I sent a rough draft of the paper to Mr. David M. Nesbit, of London, who kindly sends the following criticism:

"Your aim, as I understand it, is to lay before your audience an historical review of the development of warming and ventilation from the time of Buchanan down to the present day. You have indeed paid my country a great tribute in associating, as you have done, its connection with the arts of warming and ventilation through the names of Buchanan, Reid, Galton, Hood, and others, but I think in doing so you only accentuate the fact, as it appears in my mind, that you (the men of America, I mean) are part and parcel of this smaller island. In criticising Hood's remarks at the meeting at which the late lamented Robert Briggs read a paper, it must not be forgotten that Hood was essentially a hot water engineer and practiced little, as far as I know, with steam as a heat agent. At the time you mention I should think very little was known in Great Britain as to what Walworth, Nason, and other pioneers were doing toward the advancement of steam heating on your side of the Atlantic. Even at the present day (1894) discredit is thrown upon steam heating by these men who practice warming and ventilation in Great Britain, using hot water as the heating medium, because they have not made acquaintance with the principles and intricacies of steam heating as applied in your country. Prejudice, one way or the other, also becomes a great factor in discussing subjects of this kind, but I am sure that if Hood was alive to-day he would not describe the steam heating, as pro-

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nounced by Mr. Briggs, as the system which "had been practiced extensively for the last 50 years in England." I think with you that students of this art should thoroughly digest the works of Billings for ventilation, Baldwin for steam heating, and Hood for hot water. These men write their books in such a practical style that little doubt would be left in the unbiased mind of the student in search of truth relating to this honorable and exacting calling. Like yourself, I am a great believer in mechanical ventilation, believing that there is much work to be done; this can only be achieved by the expenditure of energy in some form or other. It is difficult to lay down hard and fast rules for this or that system to be employed always, as circumstances alter the case often, and it would be to the best interests of many clients if they were to consult warming and ventilating engineers a little oftener before they themselves settle that this or that system should be employed. I gather from your paper that you advocate pressure fans (fan blowers) in preference to the open blade type of fan (disk fans); there, I think, I should somewhat differ with you. The latter form of fan, no doubt, is open to some objection, but why it favors itself, in my mind, is the fact that large main ducts must be employed, which can readily be got at for repairs to the heating apparatus, and to see that the ducts themselves are kept scrupulously clean; unless the engineer or janitor in charge sees to this part of his duty, then I think much of the value of such a system is taken away by their getting foul and dirty; oftentimes, I regret to say, through sheer idleness and carelessness. I have, I must say, a very open mind on the subject and may alter my opinion when I have tried a few more pressure fans.

"Like yourself, I have no patience with these men who write books simply to air their own crotchets and advertise their own wares; however well meaning the writers of such books or pamphlets may be, they lose a great deal of caste in the eyes of the general public by such artifices. We have in England at the present time such trade dodges as you mention, one firm in particular who make a specialty of so-called automatic ventilation (miscalled, I say) sending broadcast anonymous circulars setting forth the great merit of automatic ventilation over that of the mechanical system. These circulars, in the majority of cases, I am pleased to say, find their proper resting place, viz., the waste-paper basket. I hope to be privileged to live to see the day when we, in this country (England) shall be able to show our American cousins some as fine installations as I had the pleasure of inspecting in your country this year (1894)."

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INDEX TO VOLUME I.

Address, President's, E. P. Bates..... 51
Air Delivery in Simple Indirect and Fan System Plants, versus Plenum Chamber Systems, Current System of, Topic No. 10.... 247
Architects, Relation of Heating and Ventilating Engineer to..... 13
Automatic Air and Water Valves on Steam Systems, Necessity of, Topic No. 7..... 242

Baldwin, Wm. J., Disc. on Determining the Heating Power of Heating Systems, 64, 66, 70, 72; Disc. on Future of Electric Heating, Topic No. 6, 240, 241; Disc. on Heating and Ventilating of School Buildings, 96; Disc. on Size of Risers, Topic No. 4, 233; Ventilation of the Subways of New York..... 27

Barron, H. J., The Literature of Heating and Ventilating, 173; Disc. on Advantage of Metal over Wooden Cold Air Conduits, Topic No. 17, 253; Disc. on Circulation in Hot Water Heaters, Topic No. 15, 252; Disc. on Construction of Hot Water Radiators, 156; Disc. on Determining the Heating Power of Heating Systems, 63, 69, 70; Disc. on Heating and Drying by Exhaust and Live Steam, 217, 219, 220, 222; Disc. on Heating and Ventilation of School Buildings, 81, 95; Disc. on Joints in Sectional Steam and Hot Water Heaters, Topic No. 16, 252, 253; Disc. on Necessity of Automatic Air and Water Valves on Steam Systems, Topic No. 7, 243, 244, 246; Disc. on Sizes of Risers, Topic No. 4, 232, 235; Disc. on Testing of Steam Radiators, 134; Disc. on The Heating and Ventilating Engineer, 202; Disc. on Use of Mushroom Registers, Topic No. 20, 257, 258; Disc. on Value of Standing Committees on Tests and Standards, Topic No. 12, 250; Disc. on Wrought Iron and Steel Pipe,
Bates, E. P., President's Address, 51; Disc. on The Heating and
Topic No. 18..... .....255, 256, 257
Ventilating Engineer..... 208
Blackmore, J. J., Disc. on Determining the Heating Power of Heating Systems, 59; Disc. on Mixing Dampers in Plenum System of Heating and Ventilation, Topic No. 2, 231; Disc. on Sizes of Risers, Topic No. 4, 234; Disc. on Testing of Steam Radiators, 138; Disc. on The Heating and Ventilating Engineer..... 206
Board of Managers, Election of, 22; Report of..... 7

Carpenter, B. H., Disc. on Heating and Ventilation of School Buildings, 83, 92, 94; Disc. on Necessity of Automatic Air and Water Valves on Steam Systems, Topic No. 7, 243, 246; Disc. on Wrought Iron and Steel Pipe, Topic No. 18..... 256

Digitized by Google

Carpenter, Prof. R. C., Testing of Steam Radiators, 98; Disc. on The Heating and Ventilating Engineer..... 213
Circulation in Hot Water Heaters, Topic No. 15..... 252
Cobb, Geo. H., Disc. on Joints in Sectional Steam and Hot Water Heaters, Topic No. 16, 253; Disc. on Wrought Iron and Steel Pipe, Topic No. 18..... 256
Cold Air Inlets to Hot Air Furnaces, Proportion for, Topic No. 13.. 250
Committee, Appointment of Nominating, 7; Report of Nominating, 14; on Compulsory Legislation, 44; on Standards, 44; on Tests, 44; on Uniform Contract and Specification, Appointment of, 25; Increase in Membership of..... 29
Committees on Tests and Standards, Value of Standing, Topic No. 12..... 249
Compensation for Plans and Specifications, Topic No. 19..... 257
Competition, Common Specification and, Topic No. 11..... 249
Compulsory Legislation, Committee on..... 44
Conduits, Advantage of Metal over Wooden Cold Air, Topic No. 17. 253
Construction of Hot Water Radiators, A Short Talk on, J. J. Wilson..... 146
Cooling of Water in Radiators, Topic No. 21..... 258
Council, Election of..... 22
Current System of Air Delivery in Simple Indirect and Fan System Plants versus Plenum Chamber Systems, Topic No. 10..... 247

Dampers, Mixing, in Plenum System of Heating and Ventilation, Topic No. 2..... 229
Determining the Heating Power of Heating Systems, J. H. Kinealy. 54
Discussion on Semi-Annual Meeting..... 29
Discussions, Topical..... 223
Drying by the Use of Exhaust Steam and Live Steam Reduced to Low Pressure, Heating and, A. A. Hunting..... 214

Efficiency of Extended Surface in Steam and Water Radiators, Topic No. 14..... 251
Electing Officers, System of..... 19
Election of Board of Managers, 22; First Vice-President, 20; Council, 22; President, 19, 42; Second Vice-President, 20; Secretary, 21; Third Vice-President, 20, 43; Treasurer..... 21
Electrical Heating, Future of, Topic No. 6..... 236
Engineer, Heating and Ventilating, A Commercial View..... 198
Exhaust Fans, Propulsion and, Topic No. 8, 247; Steam and Live Steam Reduced to Low Pressure, Heating and Drying by, A. A. Hunting..... 214

Fan System Plants versus Plenum Chamber Systems, Current System of Air Delivery in Simple, Indirect and, Topic No. 10..... 247
Fans, Propulsion and Exhaust, Topic No. 8..... 247
First Vice-President, Election of..... 20
Fish, John A., Disc. on Construction of Hot Water Radiators, 149, 151, 153, 156..... 158
Furnaces, Proportion for Cold Air Inlets to Hot Air, Topic No. 13.... 250
Future of Electrical Heating, Topic No. 6..... 236

Digitized by Google

Harding, J. A., Disc. on Construction of Hot Water Radiators, 149, 150, 153, 156; Disc. on Heating and Drying by Exhaust and Live Steam, 218, 221, 222; Disc. on Heating and Ventilation of School Buildings, 86, 88, 91, 94, 96, 97; Disc. on Mixing Dampers in Plenum System of Heating and Ventilation, Topic No. 2, 230, 231; Disc. on Use of Mushroom Registers, Topic No. 20, 258; Disc. on Sizes of Risers, Topic No. 4, 233; Disc. on Testing of Steam Radiators, 135, 141; Disc. on The Heating and Ventilating Engineer..... 212

Hart, L. H., Disc. on Future of Electric Heating, Topic No. 15.....237, 239, 240

Heaters, Circulation in Hot Water, Topic No. 15, 252; Joints in Sectional, Topic No. 16..... 252

Heating and Drying by the use of Exhaust Steam, and Live Steam Reduced to low Pressure, Either Separately or in Combination, Alfred A. Hunting, 214; Ventilating Engineer—A Commercial View, S. A. Jellett, 198; Literature of, Hugh J. Barron, 173; Method of, Topic No. 1, 223; Plant, A Prison, H. B. Prather 160; Ventilation, Mixing Dampers in Plenum System of, Topic No. 2, 229; of School Buildings, T. J. Waters, 75; Future of Electric, Topic No. 6, 236; Power of Heating Systems, Determining the, J. H. Kinealy, 54; Surface, Water Condensed per 100 Square Feet per Hour, Topic No. 3..... 232

Hopkins, Chas. S., Disc. on Determining the Heating Power of Heating Systems, 67; Disc. on Testing of Steam Radiators, 144; Disc. on The Heating and Ventilating Engineer, ... 206

Hot-Water Radiators, A Short Talk on the Construction of, J. J. Wilson..... 146

Hunting, A. A., Heating and Drying by the use of Exhaust Steam and Live Steam Reduced to Low Pressure, Either Separately or in Combination..... 214

Indirect and Fan System Plants versus Plenum Chamber Systems, Current System of Air Delivery in Simple, Topic No. 10..... 247

Inlets to Hot Air Furnaces, Proportion for Cold Air, Topic No. 13.. 250

Jellett, S. A., Ventilating Engineer—A Commercial View, 198; Disc. on Determining the Heating Power of Heating Systems, 60, 61 67, 72; Disc. on Future of Electric Heating, Topic No. 6. 236, 239 241; Disc. on Heating and Ventilation of School Buildings 88, 92, 94, 95; Disc. on Method of Heating and Ventilating, Topic No. 1, 223, 225, 228; Disc. on Necessity of Automatic Air and Water Valves on Steam Systems, Topic No. 7, 242, 243, 245, 246; Disc. on Prison Heating and Ventilating Plant, 170; Disc. on Sizes of Risers, Topic No. 4, 233, 234; Disc. on Testing of Steam Radiators, 135, 143, 144; Disc. on The Heating and Ventilating Engineer,..... 203

Joints in Sectional Heaters, Topic No. 16 252

Kinealy, J. H., Determining the Heating Power of Heating Systems,..... 54

Digitized by Google

Legislation, Committee on Compulsory..... 44
Light, Maj. H. E., Disc. on Cooling of Water in Radiators, Topic No. 21, 258, 259; Disc. on Determining the Heating Power of Heating Systems, 67,72,74; Disc. on Future of Electric Heating, Topic No. 6, 240; Disc. on Mixing Dampers in Plenum System of Heating and Ventilation, Topic No. 2, 229, 230, 231; Disc. on Sizes of Risers, Topic No. 4, 236; Disc. on The Heating and Ventilating Engineer, 205, 210; Disc. on Value of Standing Committees on Tests and Standards, Topic No. 12, 250; Disc. on Wrought Iron and Steel Pipe, Topic No. 18 255
Literature of Heating and Ventilating, Hugh J. Barron..... 173

Mackay, W. M., Disc. on Construction of Hot Water Radiators, ...150, 154, 155
Metal over Wooden Cold Air Conduits, Advantages of, Topic No. 17. 253
Method of Heating and Ventilating, Topic No. 1..... 223
Minimum Standard of Ventilation, Topic No. 9..... 247
Mixing Dampers in Plenum System of Heating and Ventilation, Topic No. 2..... 229
Mushroom Registers, Topic No. 20..... 257

Newton, Chas. W., Resignation of 32
Nominating Committee, Appointment of, 7; Report of,..... 14

Officers, System of Electing..... 19
Onderdonk, C. S., Disc. on Heating and Drying by Exhaust and Live Steam, 216; Disc. on Method of Heating and Ventilating, Topic No. 1, 223, 226, 227, 228; Disc. on Mixing Dampers in Plenum System of Heating and Ventilation, Topic No. 2, 230, 231; Disc. on Sizes of Risers, Topic No. 4, 236; Disc. on Testing of Steam Radiators, 145; Disc. on The Heating and Ventilating Engineer, ...202, 207, 208
Organization of the Society.....(See Preface) 3

Prather, H. B., A Prison Heating and Ventilating Plant, 160; Disc. on Current Systems of Air Delivery in Simple Indirect and Fan System Plants versus Plenum Chamber Systems, Topic No. 10...247
President's Address, E. P. Bates..... 51
President, Election of.....19, 42
Pipe, Wrought Iron and Steel, Topic No. 18 254
Plans and Specifications, Compensation for, Topic No. 19..... 257
Plenum Chamber Systems, Current System of Air Delivery in Simple Indirect and Fan System Plants versus, Topic No. 10, 247; System of Heating and Ventilation, Mixing Dampers in, Topic No. 2, ... 229
Prison Heating and Ventilating Plant; H. B. Prather..... 160
Proportion for Cold Air Inlets to Hot Air Furnaces, Topic No. 13.. 250
Propulsion and Exhaust Fans, Topic No. 8..... 247

Quay, D. M., Disc. on Determining the Heating Power of Heating Systems, 59, 61, 65, 71; Disc. on Heating and Drying by Exhaust and Live Steam, 220; Disc. on Joints in Sectional Steam and Hot Water Heaters, Topic No. 16..... 252

Digitized by Google

Quay, D. M., Disc. on Necessity of Automatic Air and Water Valves on Steam Systems, Topic No. 7, 246; Disc. on Testing of Steam Radiators, 142; Disc. on Use of Mushroom Registers, Topic No. 20, 258; Disc. on Value of Standing Committees on Tests and Standards, Topic No. 12, 249; Disc. on Wrought Iron and Steel Pipe, Topic No. 18,.... 254, 256

Radiators, A Short Talk on the Construction of Hot Water, J. J. Wilson, 146; Cooling of Water in, Topic No. 21, 258; Efficiency of Extended Surface in Steam and Water, Topic No. 14, 251; Testing of Steam Radiators, Prof. R. C. Carpenter..... 98
Registers, Mushroom, Topic No. 20,..... 257
Report ofBoard of Managers,7; Secretary, 6; Treasurer..... 6
Resignation of Chas. W. Newton..... 32
Risers, Sizes of, Topics Nos. 4, and 5..... 232
Russell, Wm. A., Disc. on The Heating and Ventilating Engineer... 210

School Buildings, Heating and Ventilation of, T. J. Waters..... 75
Second Vice President, Election of..... 20
Secretary, Election of, 21; Report of..... 6
Sectional Heaters, Joints in, Topic No. 16..... 252
Semi-annual Meeting, Discussion on..... 29
Seward, P. H., Disc. on Construction of Hot Water Radiators..... 154
Short Talk on the Construction of Hot Water Radiators, J. J. Wilson 146
Sizes of Risers, Topics Nos. 4 and 5 232
Smith, Fred. P., Disc. on Determining the Heating Power of Heating Systems, ...62, 64, 65, 66, 68, 71, 74
Specifications and Competition, Topic No. 11, 249; Compensation for Plans and, Topic No. 19..... 257
Standard of Ventilation, Minimum, Topic No. 9..... 247
Standards, Committee on, 44; Value of Standing Committees on Tests and, Topic No. 12..... 249
Steam Systems, Necessity of Automatic Air and Water Valves on, Topic No. 7 242
Steel Pipe, Wrought Iron and, Topic No. 18..... 254
Subways of New York, Ventilation of, Wm. J. Baldwin..... 27
System of Electing Officers..... 19
Systems, Determining the Heating Power of Heating, J. H. Kinealy. 54

Tests and Standards, Value of Standing Committees on, Topic No. 12, 249; Committee on 44
Third Vice President, Election of.....20, 43
Topical Discussions 223
Treasurer, Election of, 21; Report of,..... 6

Uniform Contract and Specifications, J. L. Wells, 45, 47, 48; Appointment of Committee on, 25; Increase in Membership of Committee on, ... 29

Value of Standing Committees on Tests and Standards, Topic No. 12, 249
Valves on Steam Systems, Necessity of Automatic Air and Water, Topic No. 7 242

Digitized by Google

Ventilating Engineers, Heating and — A Commercial View, S. A. Jellett, 198; Literature of Heating and, Hugh J. Barron, 173; Method of Heating and, Topic No. 1, 223; Plant, A Prison Heating and, H. B. Prather 160
Ventilation, Minimum Standard of, Topic No. 9, 247; Mixing Dampers in Plenum System of Heating and, Topic No. 2, 229; of School Buildings, Heating and, T. J. Waters, 75; The Subways of New York, Wm. J. Baldwin..... 27

Wade, Rufus R., letter from..... 9
Water Condensed per 100 Square Feet of Heating Surface per Hour, Topic No. 3, 232; in Radiators, Cooling of, Topic No. 21, 258; Valves on Steam Systems, Necessity of Automatic Air and, Topic No. 7..... 242
Waters, T. J., Heating and Ventilation of School Buildings..... 75
Wells, J. L., Disc. on Necessity of Automatic Air and Water Valves on Steam Systems, Topic No. 7, 245; Uniform Contract and Specification..... ...45, 47, 48
Wilkinson, W. B., Disc. on Proportion of Cold Air Inlets to Hot Air Furnaces, Topic No. 13, 250; Disc. on Wrought Iron and Steel Pipe, Topic No. 18 255
Wilson, J. J., A short Talk on the Construction of Hot Water Radiators, 146; Disc. ou Construction of Hot Water Radiators, 149, 150, 155, 159; Disc. on Cooling of Water in Radiators, Topic No. 21, 258; Disc. on Determining the Heating Power of Heating Systems, 59; Disc. on Heating and Ventilation of School Buildings, 88; Disc. on Joints in Sectional Steam and Hot Water Heaters, Topic No. 16, 252, 253; Disc. on Testing of Steam Radiators 142
Wooden Cold Air Conduits, Advantage of Metal over, Topic No. 17. 253
Wrought Iron and Steel Pipe, Topic No. 18..... 254

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INDEX TO VOLUME II.

Address, President's, S. A. Jellett..... 68
Advantages of Various Systems of Piping, Topic No. 6..... 222
Air Heaters 86
Air Valves, Float and Expansion Automatic, Topic No. 17..... 235
Air Warmed per Minute by a Square Foot of Heating Surface in a Heating Drum, Number of Cubic Feet of, Topic No. 10..... 229
Andrus, N. P., Disc. on Heating and Ventilating of Large Churches, 107; Disc. on Methods of Insulating Underground Systems of Steam Piping, 135; Disc. on Screwed Fittings for High Pressure..... 202
Applications of Electric Heating, Industrial, 87; Practical..... 83
Appointment of Committee on Tests, 55; Uniform Contract and Specifications, 55; to change the By-law Governing the Method of Voting for Officers, 29; Compulsory Legislation, 55; Nominating Committee..... 23
Area of Chimneys for House Heating Boilers, Form and, Topic No. 20 235

Barron, H. J., Screwed Fittings for High Pressure, 196; Disc. on Economy in Returning Water of Condensation, Topic No. 31, 248; Disc. on Float and Expansion Automatic Air Valves, Topic No. 17, 235; Disc. on Float and Pot Traps, Topic No. 26, 245; Disc. on Forced Blast Warming with Furnaces, 162; Disc. on Heating and Ventilating of Large Churches, 104, 107; Disc. on Ideal System of Heating for Moderate Sized Dwellings, Topic No. 1, 208; Disc. on Methods of Insulating Underground Systems of Steam Piping, 133; Disc. on One-Pipe System of Steam Heating, 241; Disc. on Opening in Seat of Radiator Valves, Topic No. 16, 234; Disc. on Return of Condensation from Fan Heaters to Boilers, Topic No. 30..... 248
Blackmore, J. J., Disc. on Forced Blast Warming with Furnaces, 157, 160, 163, 169; Disc. on Ideal System of Heating for Moderate Sized Dwellings, Topic No. 1..... 207
Blast Pressure Gauge, A Draft and, J. H. Kinealy..... 109
Board of Managers, 3; Election of, 48; Report of..... 8
Boilers, Cause of Priming and Foaming in House Heating, Topic No. 28, 246; Form and Area of Chimneys for House Heating, Topic No. 20, 235; Rating of House Heating, Topic No. 13, 229; Return of Condensation from Fan Heaters to, Topic No. 30, 247; Water Contained by House Heating Steam in Proportion to their Grate and Fire Surface, Topic No. 15 232

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Car Heating 83
Carpenter, B. H., Disc. on Effect of Color on Radiating Power of Radiators, Topic No. 7, 226; Disc. on Fan System of Warming, Topic No. 8, 227; Disc. on Forced Blast Warming with Furnaces, 159, 161; Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 239; Disc. on Heating and Ventilating of Large Churches, 105, 106; Disc. on Methods of Insulating Underground Systems of Steam Piping, 135; Disc. on Specifying Temperature, Topic No. 9..... 228
Carpenter, R. C., Methods of Insulating Underground Systems of Steam Piping, 119; Disc. on Advantages of Various Systems of Piping, Topic No. 6, 222; Disc. on Draft and Blast Pressure Gauge, 111, 114, 115; Disc. on Effect of Color on Radiating Power of Radiator, Topic No. 7, 225, 226, 227; Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 237; Disc. on Heat Units Given off by Convection and Radiation, Topic No. 22, 241; Disc. on Methods of Insulating Underground Systems of Steam Piping, 134, 136, 137, 142; Disc. on Screwed Fittings for High Pressure..... 200
Cary, A. A., Disc. on Cause of Priming and Foaming in House Heating Boilers, Topic No. 28, 246; Disc. on Cooling of Closed Rooms, 190, 194; Disc. on Draft and Blast Pressure Gauge, 111, 114; Disc. on Food for Thought, 205; Disc. on Forced Blast Warming with Furnaces, 165, 167; Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 235, 239, Disc. on Heating and Ventilating of Large Churches, 105, 107; Disc. on Ideal System of Warming Moderate Sized Dwellings, Topic No. 1, 207, 208, 210; Disc. on Methods of Insulating Underground Systems of Steam Piping, 129, 131, 132, 133, 135, 142; Disc. on Screwed Fittings for High Pressure, 198, 199; Disc. on Semi-annual Meeting 42, 43, 45, 46; Disc. on Steam Loop, Topic No. 14..... 229
Cause of Priming and Foaming in House Heating Boilers, Topic No. 28..... 246
Chimneys for House Heating Boilers, Form and Area of, Topic No. 20 235
Churches, Heating and Ventilating of Large, H. B. Prather..... 92
Clark, W. H., Disc. on Methods of Insulating Underground Systems of Steam Piping 130, 132, 133
Closed Rooms, Cooling of, H. Eisert, ... 172
Combination System of Heating, Fan and Furnace, Topic No. 4.... 221
Committee, Appointment of Nominating, 23; on Compulsory Legislation, 4; Appointment of, 55; Report of, 14; on Change of By-law Governing the Method of Voting for Officers, Report of, 35; Nominations, Report of, 38; Standards, 4; Report of, 11; Tests, 4; Appointment of, 55; Uniform Contract and Specifications, 4; Appointment of, 55; Report of 49
Compulsory Legislation, Appointment of Committee on, 55; Report of 14
Condensation, Economy in Returning Water of, Topic No. 31, 248;

Digitized by Google

Condensation from Fan Heaters to Boilers, Return of, Topic No. 30, 247; Steam Loop for Return of Water of, Topic No. 14..... 229
Connolly, J. A., Disc. on Forced Blast Warming with Furnaces, 160; Disc. on Heating and Ventilating of Large Churches, 107, 108; Disc. on Location of Hot Air Flues, Topic No. 23, 243; Disc. on Return of Condensation from Fan Heaters to Boilers, Topic No. 30 248
Convection and Radiation, Heat Units Given off by, Topic No. 22... 241
Cooking, Electric 86
Cooling of Closed Rooms, H. Eisert 172
Council, 3; Election of, 46; Report of..... 9

Davidson, McC., Disc. on Quantity of Water House Heating Steam Boilers Contain in Proportion to their Grate and Fire Surface, Topic No. 15..... 232
Dean, M. E., Disc. on Cause of Priming and Foaming in House Heating Boilers, Topic No. 28, 247; Disc. on Economy in Returning Water of Condensation, Topic No. 31, 248; Disc. on Forced Blast Warming with Furnaces, 170; Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 238; Disc. on Heating and Ventilating of Large Churches..... 105
Direct and Indirect Radiators, System of Piping for, Topic No. 5.... 221
Discussions, Topical 207
Draft and Blast Pressure Gauge, J. H. Kinealy..... 109
Ducts in Fan System of Warming, Loss in Transmission through Horizontal, Topic No. 11..... 229
Dwellings, Ideal System of Heating Moderate Sized, Topic No. 7... 207

Economy in Heating as Effected by Large Piping, Topic No. 24, 244; in Returning Water of Condensation, Topic No. 31..... 248
Eisert, H., The Cooling of Closed Rooms 172
Election of Board of Managers, 46; First Vice-President, 40; Second Vice-President, 40; Secretary, 40; Council, 46; Third Vice-President, 40; Treasurer, ... 41
Electric Cooking..... 86
Electric Heating, W. S. Hadaway, 73; Industrial Applications of, 87; Practical Applications of 83
Equalizing a Gravity System, Topic No. 12..... 229
Expansion Automatic Air Valves, Float and, Topic No. 17..... 235

Fan and Furnace Combination System of Heating, Topic No. 4, 221; System of Warming, Drawing or Forcing Air through Heater in, Topic No. 8, 227; Loss in Transmission through Horizontal Ducts in, Topic No. 11..... 229
Fire Surface, Water Contained by House Heating Steam Boilers in Proportion to their Grate and, Topic No. 15..... 232
First Vice-President, Election of 40
Fish, J. A., Disc. on Advantages of Various Systems of Piping, Topic No. 6, 223; Disc. on Cooling of Closed Rooms, 194; Disc. on Effect of Color on Radiating Power of Radiators, Topic No. 7, 226; Disc. on Heating and Ventilating of Large Churches, 105, 107, 108

Digitized by Google

Fish, J. A., Disc. on Methods of Insulating Underground Systems of Steam Piping, 137; Disc. on Rating of House Heating Boilers, Topic No. 13, 229; Disc. on Relative Merits of the Overhead System, the Usual 2-Pipe Method, and the Single Pipe Main with 2-Pipe Risers in Hot Water Heating, Topic No. 3, 216, 218, 219, 220; Disc. on Screwed Fittings for High Pressure, 199, 202; Disc. on System of Piping for Direct and Indirect Radiators, Topic No. 5.....221, 222
Float and Expansion Automatic Air Valves, Topic No. 17, 235; Pot Traps, Topic No. 26 245
Flue Radiators, and Other Types, Relative Merits of, Topic No. 19... 235
Flues, Location of Hot Air, Topic No. 23..... 241
Foaming in House Heating Boilers, Priming and, Topic No. 28..... 246
Forced Blast Warming with Furnaces, G. W. Kramer..... 144
Food for Thought W. H. McKiever..... 203
Form and Area for Chimneys for House Heating Boilers, Topic No. 20, 235; of Hot Air Registers, Topic No. 27..... 245
Fuel Economy of Different Systems of School House Heating and Ventilating, Topic No. 25..... 244
Furnace Combination System of Heating, Fan and, Topic No. 4 221
Furnaces, Forced Blast Warming with, G. W. Kramer..... 144

Gauge, Draft and Blast Pressure, J. H. Kinealy..... 109
Gormly, J., Disc. on Electric Heating, 88; Disc. on Food for Thought, 206; Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 239; Disc. on Ideal System of Heating for Moderate Sized Dwellings, Topic No. 1, 207, 208; Disc. on Opening in Seat of Radiator Valves, Topic No. 16..... 234
Grate and Fire Surface, Water Contained by House Heating Steam Boilers in proportion to their, Topic No. 15 232
Gravity System, Equalizing a, Topic No. 12..... 229

Hadaway, W. S., Electric Heating, 73; Disc. on Electric Heating 88, 89, 91
Harvey, A., Disc. on Electric Heating, 90; Disc. on Heating and Ventilating of Large Churches, 107; Disc. on Methods of Insulating Underground Systems of Steam Piping.....134, 142
Heater in Fan System of Warming, Drawing or Forcing Air Through, Topic No. 8 227
Heaters, Air, 86; to Boilers, Return of Condensation from Fan, Topic No. 30 247
Heating and Ventilating, Fuel Economy of different Systems of School House, Topic No. 25, 244; of Large Churches, H. B. Prather, 92; School Houses, Topic No. 18, 235; as Effected by Large Piping, Economy in, Topic No. 24, 244; Car, 83; Electric, W. S. Hadaway, 73; Fan and Furnace Combination System of, Topic No. 4, 221; Indirect Radiation in Hot Water, Topic No. 29, 247; Industrial Applications of Electric, 87; Moderate Sized Dwellings, Ideal System of, Topic No. 1, 207; One-Pipe System of Steam, Topic No. 21, 241; Practical Applications of Electric. 83
Heat Units given off by Convection and Radiation, Topic No. 22... 241

Digitized by Google

High Pressure, Screwed fittings for, H. J. Barron..... 196
Hoffman, G. D., Disc. on Advantages of Various Systems of Piping, Topic No. 6, 224; Disc. on Cooling of Closed Rooms, 190, 195; Disc. on effect of Color on Radiating Power of Radiators, Topic No. 7, 226, 227; Disc. on Food for Thought, 204; Disc. on Number of Cubic Feet of Air Warmed per minute by a Square Foot of Heating Surface in Heating Drum, Topic No. 10..... 229
Hot Air Flues, Location of, Topic No. 23, 241; Registers, Form of Topic No. 27, 245; Water Heating, Indirect Radiation in, Topic No. 29..... 247
House Heating Boilers, Cause of Priming and Foaming in, Topic No. 28, 246; Form and Area of Chimneys for, Topic No. 20, 235; Rating of, Topic No. 13, 229; Water Contained in Proportion to Their Grate and Fire Surface, Topic No. 15..... 232

Ideal System of Heating Moderate Sized Dwellings, Topic No. 1.... 207
Indirect Radiation in Hot Water Heating, Topic No. 29, 247; Radiators, System of Piping for Direct and, Topic No. 5..... 221
Industrial Applications of Electric Heating..... 87
Insulating Underground Systems of Steam Piping, Methods of, R. C. Carpenter 119

Jellett, S. A., President's Address, 68; Disc. on Advantages of Various Systems of Piping, Topic No. 6, 223, 224; Disc. on Cooling of Closed Rooms, 191, 194; Disc. on Drawing or Forcing Air through Heater in Fan System of Warming, Topic No. 8, 227; Disc. on Electric Heating, 88; Disc. on Food for Thought, 205; Disc. on Form of Hot Air Registers, Topic No. 27, 245; Disc. on Location of Hot Air Flues, Topic No. 23, 242, 243; Disc. on Methods of Insulating Underground Systems of Steam Piping, 138; Disc. on System of Piping for Direct and Indirect Radiators, Topic No. 5, 221; Disc. on Ventilation of Office Buildings, Topic No. 2.....211, 214, 215, 216

Kenrick, A. E., Disc. on Cause of Priming and Foaming in House Heating Boilers, Topic No. 28, 247; Disc. on Location of Hot Air Flues, Topic No. 23..... 244
Kent, Wm., Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 236, 238, 239, 240; Disc. on Quantity of Water Contained by House Heating Steam Boilers in Proportion to their Grate and Fire Surface, Topic No. 15, 233; Disc. on Screwed Fittings for High Pressure..... 199
Kramer, Geo. W., Forced Blast Warming with Furnaces, 144; Disc. on Forced Blast Warming with Furnaces, 157, 158, 159, 160, 161, 170

Legislation, Appointment of Committee on Compulsory, 55; Report of Committee on Compulsory..... 14
Location of Hot Air Flues, Topic No. 23 241
Loop, Steam, for Return of Water of Condensation, Topic No. 14.... 229

Mackay, W. M., Disc. on Forced Blast Warming with Furnaces, 159 168, 169; Disc. on Methods of Insulating Underground Systems of Steam Piping, 133; Disc. on Semi-annual Meeting..... 43

Digitized by Google

Managers, Election of Board of, 46; Report of Board of..... 8
Merits of Flue Radiators and Other Types, Relative, Topic No. 19... 235
Methods of Insulating Underground Systems of Steam Piping, R. C. Carpenter 119
Milligan, A., Disc. on Ventilation of Office Buildings, Topic No. 2, ...213, 214, 215, 216
Nominating Committee, Appointment of, 23; Report of..... 38
Office Buildings, Ventilation of, Topic No. 2..... 211
Officers, Appointment of Committee to Change the By-law Governing the Method of Voting for, 29; Report of Committee, 35; of the Society 3
One-Pipe System of Steam Heating, Topic No. 21..... 241
Payne, J. A., Disc. on Cooling of Closed Rooms, 194; Disc. on Economy in Returning Water of Condensation, Topic No. 31, 248; Disc. on Float and Expansion Automatic Air Valves, Topic No. 17, 235; Disc. on Forced Blast Warming with Furnaces, 158; Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 238; Disc. on Ideal System of Heating for Moderate Sized Dwellings, Topic No. 1, 208; Disc. on Location of Hot Air Flues, Topic No. 23, 244; Disc. on Merits of the Overhead System, the Usual 2-Pipe Method, and the Single Pipe Main with 2-Pipe Risers in Hot Water Heating, Topic No. 3, 219, 221; Disc. on Methods of Insulating Underground Systems of Steam Piping, 136; Disc. on Opening in Seat of Radiator Valves, Topic No. 16, 234, 235; Disc. on Return of Condensation from Fan Heaters to Boilers, Topic No. 30, 248; Disc. on Specifying Temperature, Topic No. 9, 228; Disc. on Use of Steam Loop for Returning Condensation, Topic No. 14..... 230
Piping, Advantages of Various Systems of, Topic No. 6, 222; Economy in Heating as Effected by Large, Topic No. 24, 244; for Direct and Indirect Radiators, System of, Topic No. 5..... 721
Pot Traps, Float and, Topic No. 26..... 245
Practical Applications of Electric Heating 83
Prather, H. B., Heating and Ventilating Large Churches, 92; Disc. on Forced Blast Warming with Furnaces..... 155
President's Address, S. A. Jellett..... 68
Pressure Gauge, A Draft and Blast, J. H. Kinealy, 109; Screwed Fittings for High, H. J. Barron..... 196
Priming and Foaming in House Heating Boilers, Topic No. 28..... 246
No. 28..... 246
Quay, D. M., Disc. on Advantages of Various Systems of Piping, Topic No. 6, 223, 224; Disc. on Forced Blast Warming with Furnaces, 160, 167, 171; Disc. on Ideal System of Heating for Moderate Sized Dwellings, Topic No. 1, 207, 209; Disc. on Merits of the Overhead System, the Usual 2-Pipe Method, and the Single Pipe Main with 2-Pipe Risers in Hot Water Heating, Topic No. 3, 220; Disc. on Methods of Insulating Underground Systems of Steam Piping, 141; Disc. on Semi-annual Meeting.... 42, 44

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Radiation, Heat Units Given off by Convection and, Topic No. 22, 241
Radiators, Relative Merits of Flue and Other Types, Topic No. 19; 235; System of Piping for Direct and Indirect, Topic No. 5.... 221
Rating of House Heating Boilers, Topic No. 13..... 229
Registers, Form of Hot Air, Topic No. 27..... 245
Report of Board of Managers, 8; Committee on Change of By-law Governing Method of Voting for Officers, 35; Compulsory Legislation, 14; Nominations, 38; Standards, 11; Uniform Contract and Specifications, 49; Council, 9; Secretary's, 6; Treasurer's 8..... 8
Return of Condensation from Fan Heaters to Boilers, Topic No. 30.. 247
Rooms, Cooling of Closed, H. Eisert 172

School House Heating and Ventilating, Fuel Economy of Different Systems of, Topic No. 25, 244; Houses, Heating and Ventilating, Topic No. 18..... 235
Screwed Fittings for High Pressure, H. J. Barron..... 196
Second Vice-President, Election of..... 40
Secretary, Election of 40
Secretary's Report 6
Society, Officers of the..... 3
Specifications, Committee on Uniform Contract and, 4; Appointment of, 55; Report of 49
Specifying Temperature, Topic No. 9..... 228
Standards, Committee on, 4; Report of 11
Stangland, B. F., Disc. on Ventilation of Office Buildings, Topic No. 2 214
Steam Heating, One-Pipe System of, Topic No. 21, 241; Loop for Return of Water of Condensation, Topic No. 14, 229; Steam Piping, Methods of Insulating Underground Systems of, R. C. Carpenter 119

Temperature, Specifying, Topic No. 9..... 228
Tests, Committee on, 4; Appointment of..... 55
Third Vice-President, Election of 40
Thought, Food for, W. H. McKiever..... 203
Topical Discussions 207
Transmission through Horizontal Ducts in Fan System of Warming, Loss in, Topic No. 11..... 229
Traps, Float and Pot, Topic No. 26..... 245
Treasurer, Election of..... 41
Treasurer's Report 8

Uniform Contract and Specifications, Committee on, 4; Appointment of, 55; Report of..... 49

Valves, Float and Expansion Automatic Air, Topic No. 17..... 235
Ventilating, Fuel Economy of Different Systems of School House Heating and, Topic No. 25, 244; of Large Churches, Heating and, H. B. Prather, 92; School Houses, Heating and, Topic No. 18..... 235
Ventilation of Office Buildings, Topic No. 2..... 211

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Warming, Drawing or Forcing Air through Heater in Fan System of, Topic No. 8, 227; Fan System of, Topic No. 8, 227; Loss in Transmission through Horizontal Ducts in Fan System of, Topic No. 11, 229; with Furnaces, Forced Blast, G. W. Kramer, 144
Water Contained by House Heating Steam Boilers in Proportion to their Grate and Fire Surface, Topic No. 15 232
Water of Condensation, Economy in Returning, Topic No. 31, 248; Steam Loop for Return of, Topic No. 14..... 229
Wilkinson, W. B., Disc. on Forced Blast Warming with Furnaces.. 165
Wilson, J. J., Disc. on Forced Blast Warming with Furnaces, 163; Disc. on Merits of the Overhead System, the Usual 2-Pipe Method, and the Single Pipe Main with 2-Pipe Risers in Hot Water Heating, Topic No. 3, 218; Disc. on Semi-annual Meeting 41,43,44
Wolfe, W. F., Disc. on Forced Blast Warming with Furnaces, 161, 164, 165, 167, 168, 171; Disc. on Form and Area of Chimneys for House Heating Boilers, Topic No. 20, 238; Disc. on Location of Hot Air Flues, Topic No. 23, 241, 243; Disc. on Ventilation of Office Buildings, Topic No. 2.....214, 215

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